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ABSTRACT

Research analyzed adoption of erosion control practices by farm operators in two counties in each of four states: Alabama, Missouri, Tennessee, and Washington. Analysis was based on farm survey data and technical and financial assistance information from county Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service records. Factors affecting farmers' adoption of soil conservation practices varied by owned and rented land and by state. The differences among states, tenure classes, and various dependent variables left little basis for a model that could predict adoption of practices in the areas studied. Each state contained unique characteristics; therefore, no uniform guidelines for erosion control programs appeared appropriate. Some variables were common. Strong statistical agreement was indicated that rented land on the farms surveyed was not enrolled in the erosion control targeting program at the same rate as was owned land. Previous conservation efforts and participation in previous SCS programs had a generally significant and positive effect on adoption. Other variables provided mixed signals as to strength and direction of impact on adoption. (YLB)

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United States Department of Agriculture

Economic Research Service

Agricultural Research Service

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Targeting Erosion Control

Adoption of Erosion Control Practices

A Report from a National Research Project

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TARGETING EROSION CONTROL: ADOPTION OF EROSION CONTROL PRACTICES. By Peter West (Agricultural Research Service), Herbert Hoover, and M. E. Wirth. Economic Research Service, U.S. Department of Agriculture. ERS Staff Report No. AGES860815.

ABSTRACT

Factors affecting farmers' adoption of soil conservation practices varied by owned and rented land and by state, in this four-state, eight-county analysis. The differences among states, tenure classes, and various dependent variables left little basis for a model that could predict adoption of practices in the areas studied. Each state contained unique characteristics; thus, no uniform guidelines for erosion control programs appear appropriate. However, there were some common variables. For example, there was strong statistical agreement that rented land on the farms surveyed was not enrolled in the erosion control targeting program at the same rate as was owned land. Previous conservation efforts and participation in previous Soil Conservation Service programs have a generally significant and positive effect on adoption. Other variables provided mixed signals as to strength and direction of impact on adoption.

Keywords: Targeting program, soil conservation, adoption, characteristics, participation, farm operators.

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PREFACE

Soil and water conservation problems are concentrated in limited geographic areas. But, USDA conservation efforts have been spread rather widely and uniformly throughout the Nation's agricultural areas. A national program to target conservation efforts on critical resource problem areas was launched by the U.S. Department of Agriculture in 1981.

Targeting was a central thrust of planning under the Resources Conservation Act (RCA) passed by Congress in 1979 and was seen as a way to increase the effectiveness of public expenditures on conservation. While targeting is a USDA-wide program, the key agencies in designing and implementing the program are the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS).

USDA's Agricultural Research Service (ARS) and Economic Research Service (ERS) designed and carried out research on targeting in close cooperation with SCS and ASCS at the national, state, and county levels. Objectives of the research were to: (1) analyze the delivery system used in implementing the targeting program; (2) analyze factors associated with farmers' adoption of erosion control practices and identify characteristics of farmers who are most likely to respond to future conservation programs; and (3) analyze the impacts of the targeting program on soil loss, productivity, farm income, and sediment reduction.

This research project did not address the question of whether the Federal Government should spend more or less on conservation efforts, or indeed whether it should spend any at all. Rather the research proceeded from the premise that because of past history, public interest, constituent demand, and support from both Congress and the executive branch, the USDA will continue to spend several hundred million dollars each year on conservation programs. Thus, the research question is whether greater payoff can be obtained from public investments through targeting of erosion control programs.

SCS and ASCS targeted resources for controlling water and wind erosion on crop and rangelands, water conservation, and salinity problems. The research addresses programs for controlling water erosion on croplands only, the resource problem with the highest priority on USDA's agenda, and the one to which the largest proportion of targeted funds and personnel is directed.

The design of the project recognized that the national conservation problem in the United States is really a complex of problems to which different approaches to program design and execution may be relevant. The decision was accordingly made to study the targeting program in detail in one state in each of the four major water erosion areas that USDA targeted starting in 1981: Alabama in the Coastal Plain; Missouri in the Corn Belt; Tennessee in the Mississippi Valley Uplands; and Washington in the Palouse area of the Pacific Northwest.

The general approach in the research was to start with the objectives of the targeting program; to see how these objectives were translated into an operating program in the field; and then to trace through the impacts of the program as well as possible on farmers' adoption of erosion control practices, farm incomes, and other effects.

This research to analyze factors affecting the adoption of conservation practices is considered pathbreaking. It is one of the first studies of adoption across

regions and resource situations. And the study is unique in its use of regression techniques and discriminant analysis.

The general conclusion to be drawn from this analysis is that factors affecting conservation adoption are unique to each region and locality. Accordingly, policies and programs should be flexible to account for this variability. This conclusion follows from the data and the analytic techniques used. However, as will be evident to the reader, many of the specific results of the regression work are counter-intuitive. As with all scientific inquiry, results should be considered tentative. Additional research is warranted to refine the study variables for purposes of collaborating or modifying these conclusions.

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The authors wish to acknowledge the significant contributions to this research from the following people.

- Farm operators who participated in the surveys in Barbour and Henry counties, Alabama; Daviess and Harrison counties, Missouri; Dyer and Haywood counties, Tennessee; and Columbia and Walla Walla counties, Washington.

- The SCS District Conservationists (DCs) and ASCS County Executive Directors (CEDs) in the counties listed above who participated in multiple interviews and provided a great deal of data and information about their counties and their conservation programs.

- Staff in the area and state SCS and ASCS offices in the study states of Alabama, Missouri, Tennessee, and Washington who were interviewed several times and provided a large amount of data and information, and national SCS and ASCS staff who provided information on targeting and other conservation programs.

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I. SUMMARY AND CONCLUSIONS

This report analyzes adoption of erosion control practices by farm operators in two counties in each of four states. Barbour and Henry counties in southeast Alabama; Daviess and Harrison counties in northcentral Missouri; Dyer and Haywood counties in Tennessee; and Columbia and Walla Walla counties in southeast Washington are in major water erosion areas and have agriculture that is typical of their own regions. The analysis is based on farm survey data and technical and financial assistance information from county SCS and ASCS records.

The highlights of the report are:

- Although few farm operators in any of the eight counties surveyed rated the erosion problem in the counties as very serious, the great majority rated such problems to be moderate to serious. The majority of farmers viewed their land, both owned and rented, as having a less severe erosion problem than on other farms in their country. They rated the severity of erosion on their own and rented land similarly.

- Operators and SCS disagreed substantially about the severity of soil erosion on individual farms. Nearly 70 percent of all operators reported that none of their land had a serious erosion problem, while SCS indicated that 46 percent of the same owned cropland had no serious problem.

- Farm operators were generally more concerned about soil erosion in 1983 than they were in 1980 before technical and financial assistance was targeted. Reasons given related to farmers' efforts and economic reasons in Tennessee, and agency efforts and farmer efforts in Washington.

- About 75 percent of owned cropland had received conservation treatment in 1980 in all states except Tennessee which reported only 38 percent. The proportion in 1980 on rented land was close to 50 percent. By 1983, the proportions of total cropland treated on owned land rose in every study county. Rented land showed similar improvements, but to a lesser degree.

- Past SCS activities appear to foster long-term commitments by the farmer. However, the partial renter status of some farmers appears to have negative influence on conservation adoption.

- Factors affecting adoption differ from owned to rented land, and from state to state, and depend on the way in which adoption has been measured. Many of the factors significant to adoption of erosion control practices on owned land are unimportant for adoption on rented land.

- Comparisons across dependent variables also indicate significant disagreements. Quite often a variable found to be significant for one measure of adoption is insignificant for another measure. While the differences can often be explained, the implications for future study are important. The choice of the dependent variable nearly determines the set of explanatory variables that will be significant. Comparisons among research studies for differing measures of adoption must be made carefully. Equal caution must be attached to policy decisions deriving from only studies of one type of adoption behavior. Further, comparisons of the general case dependent variables to the practice specific results reinforce the above conclusion. Factors affecting the adoption of a single specific practice may not be the same as those affecting adoption in general.

Because of the generally mixed results, each state represents a unique situation. Generalized models pooling observations across states and regions, therefore, will need to recognize that unique situations may require separately developed program guidelines for erosion control programs. Since adoption response appears to relate to region-specific phenomenon, rigid program guidelines based on a national norm could be counterproductive.

Targeting Erosion Control

Adoption of Erosion Control Practices

II. INTRODUCTION

Although there has been significant progress during the 50 years of efforts by conservation agencies, there are still many farmers who have not adopted soil conserving practices. There has been a resurgence of concern in the past decade over the long-term detrimental effects of soil erosion on agricultural productivity and water pollution. Section 208 of the Federal Water Pollution Control Act Amendments of 1972, the Soil and Water Resource Conservation Act of 1977, and the Rural Clean Water Program outlined in the Agricultural Appropriations Act of 1980, aimed at reducing agricultural sources of pollution, reflect this concern.

Reductions in the effects of soil erosion on both productivity and water quality are intimately tied to the way farmers use their land. Thus, government conservation programs provide technical and financial incentives to farmers who voluntarily adopt recommended erosion control practices. However, these programs have not resulted in the participation of enough farmers to reach erosion reduction objectives. Economists and sociologists have attempted to identify reasons why farmers do not voluntarily adopt conservation practices. Among the earliest was a series of studies undertaken at Iowa State University in the 1950's [7, 8, 19, 20].[1]

Adoption and diffusion of innovations have been among the most widely researched topics in rural sociology. From original studies on the diffusion of hybrid seed corn among farmers in Iowa, the research has expanded to include the study of adoption of other innovations [6]. Blase and Timmons [7] found that off-farm income (a means to overcome financial constraints), perceptions of soil erosion as a problem, participation in local conservation districts, and ability to borrow funds were related to soil loss reduction [7, 17].

Studies since then have found some of these variables of little importance in adopting practices. One author may find age important while another under different circumstances and assumptions may find age less important. Christensen [12], Ervin [16, 17], Nowak [29], Dillman [15], Carlson [9, 10], and Basu [5] conducted separate reviews of recent research literature on the subject and found mixed results in factors affecting adoption. Much of the discrepancy arises from unrelated studies employing varying definitions of soil erosion control and participation (usually the dependent variables) as well as different measures of independent variables. And, the studies were usually conducted at different times and places, allowing little direct comparison of results.

[1] Bracketed underscored numerals refer to items in Bibliography.

An advantage of this study of the soil conservation targeting program is that adoption behavior of farm operators was surveyed in four major soil erosion areas of the country during the same timeframe while employing constant definitions of the factors studied. This study investigated not only the various personal, farm business, and institutional factors influencing the adoption of soil conservation practices, but also assessed the strength of these relationships among the four major soil erosion areas of the country at a given point in time.

Research Objectives

Research on the targeting program was initiated by the Agricultural Research Service (ARS) and the Economic Research Service (ERS) in cooperation with the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) in late 1982.[2] This research analyzes:

1. The conservation delivery system used in implementing the targeting program.

2. Factors associated with farmers' adoption of erosion control practices (and identifies characteristics of farmers most likely to respond to future conservation programs).

3. The impacts of the targeting program on soil loss, productivity, and farm income.

This study on factors affecting adoption of soil conservation practices relates to research objective 2 above. It determines changes in farmers' conservation efforts in targeted counties since the targeting program began and assesses differences in changes among targeted counties and states. This study also investigates the effects of personal, farm business, physical, delivery system, and economic, social, and institutional variables in influencing farmers' adoption behavior.

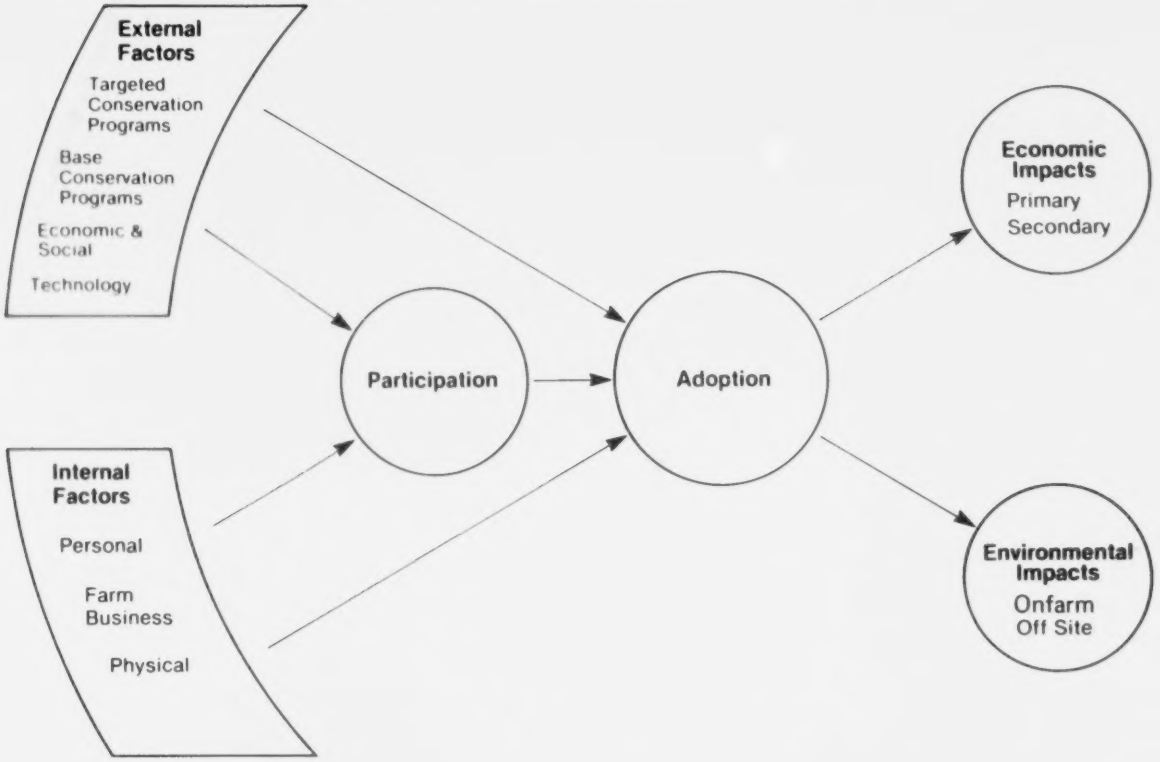
The Conceptual Model

Figure 1 presents the conceptual model for analyzing erosion control programs developed to guide this research. A variety of interacting economic, social, technological, institutional, and personal factors affect the soil conservation process. These factors may reinforce or conflict with each other in affecting farmers' behavior. This model views erosion control as a process having both economic and environmental effects highly influenced by factors of choice and circumstance. The decision to adopt erosion control is a derived result of influences both external and internal to the farm operator.

In the model presented, participation refers to farmers' participation in the conservation delivery system, including both base and targeted portions of the system. Adoption represents the use of eight state-specific erosion control practices recommended by the SCS. Adoption pertains to both the level of erosion control attained by the 1983 crop year and the change in that level since 1980. Economic impacts include the primary effects on the farm businesses in the study

[2] For details of research, conceptualization, design, and implementation, see Herbert Hoover, et al., Targeting Erosion Control: Basebook -- Methods and Data. CRR-32. U.S. Dept. Agr., July 1985. Hereafter referred to as "Basebook."

Model for Analyzing Erosion Control Programs



counties and the secondary impacts on income and employment for nonfarm business in the same study areas. Environmental effects refer to changes in soil loss, gullying, and sedimentation on the farm as well as to offsite changes and impacts due to erosion control.

Participation and adoption, key variables in the model, represent observed behavior of farmers. Figure 1 items to the left of the adoption decision circle represent factors that influence behavior, while items to the right represent the outcome of behavior. The model generally emphasizes the flow from factors influencing an outcome on the left to the results of an action on the right, while recognizing that there are two-way flows and feedback loops not shown in the model.

The model further assumes interactions among factors influencing adoption and participation in the SCS and ASCS programs (the delivery system). Participation in the delivery system will certainly influence the adoption decision, but will not necessarily determine it.[3] Farm operators often adopt erosion control

[3]It is important to differentiate participation in ASCS from that in SCS. The Soil Conservation Service provides voluntary technical assistance. The Agricultural Stabilization and Conservation Service provides financial assistance for the adoption.

practices without federal assistance. The conceptual model, therefore, shows participation to be a possible but not an exclusive route to erosion control adoption.

This reports focuses on the links among external, internal, and delivery system factors and the ultimate adoption of erosion control practices.

External Factors

External factors are beyond the ability of the farm operator to control. The farm operator may have, at times, some peripheral influence on such factors. Both targeted and base conservation programs represent influences external to the farm that affect adoption. The base conservation program consists of ongoing SCS and ASCS technical and financial assistance for soil conservation practice adoption. The targeting conservation program consists of the additional, new, or incremental activities provided by the conservation agencies aside from their ongoing activities. These additional resources are the direct result of the overall administrative decision to focus the funding of agencies upon the most critically erosive areas. Previous studies clearly indicate that the delivery system programs generally increase practice adoption [16, 17, 21, 29].

Economic and social influences external to the farm include general economic conditions, climate, farm price levels, credit market conditions, communication networks, and peer pressure. These and similar factors can certainly affect the timing of the adoption decision and even determine the feasibility of erosion control.

External technological factors of influence refer to the appropriateness of the erosion control practices to the existing farm operation. Erosion control practices are likely to be adopted in conjunction with an overall cropping pattern and perceived profitability [10]. The farm operator will evaluate the existing technology in relation to the farm's organization and evaluate the practice's ability to fit the mix of technology feasible for the farm and operator.

Internal Factors

Internal factors are primarily those under the influence and control of the farm operator, or are at least unique to an individual farm. Personal factors cover a wide range of items including age, education, risk preference, agrarianism, stewardship ethic, years on the farm, income timeframe concerns, planning horizon, nonfarm work, farm legal organization, and perceptions of erosion problems. Research generally agrees that operator education and willingness to take risk positively influences practice adoption [4, 9, 11, 14, 17, 25, 26], as do perceptions concerning erosion problems [10, 17, 21, 23, 25, 29]. Previous studies also agree that managerial ability, agrarianism, and stewardship have positive influences. However, some studies have shown that such factors as age, years farmed, kinship, and the legal organization of the farm have a negative influence on adoption. Thus the existing research base provides mixed conclusions as to the direction and significance of these factors in the adoption process [1, 3, 4, 9, 11, 17, 25, 26, 14].

Farm business factors important to the adoption process can include a broad range of variables: farm size, proportion of income from crops, gross farm income, farm assets, farm debts (either or both operating and real estate), tenure status, and rental agreements. Farm income, often measured as farm size, is generally a positive influence on adoption, while debt is an adverse factor

1, 7, 9, 10, 13, 17, 23, 29]. Ownership of the farm is another strong positive influence on adoption. Landlords who rent their land out are less likely to respond to the targeting program [2, 3, 4, 14, 16, 17, 21, 26].

Physical factors can include the severity of the erosion problem, climate, slope, rainfall, and cropping patterns. These factors have received little research attention despite their obvious importance. The basic nature of the erosion problem on the farm, soil conditions and type, and management practices influence the choice of erosion control practice.

This model is an overall guide for this study, not an exhaustive representation of the factors affecting adoption. Relevant theory, a review of the research literature, the feasibility of measuring the relationship intended, and the usefulness for future policy or program formulations were the primary considerations in a review of variables for inclusion in the statistical tests of the model.

III. DATA SOURCES AND STUDY AREA

A survey of farm operators from two counties in each of four states produced the data. These states are located in four regions of the country targeted for control of water erosion in 1981: Barbour and Henry counties in southeast Alabama (AL); Daviess and Harrison counties in northcentral Missouri (MO); Dyer and Haywood counties in west Tennessee (TN); and Columbia and Walla Walla counties in southeast Washington (WA). Agriculture in the countries was typical within the region.[4]

The farm operator surveys were conducted from late November 1983 to early February 1984. Lists of all farmowners and operators were obtained from the county ASCS offices before the samples were drawn. In six counties, the sampling area consisted of the entire county. In Dyer county, TN, Mississippi River delta land in the western edge of the county was excluded, as farmers on this delta land do not have erosion problems typical of the rest of the county. The low rainfall area in the northwest part of Walla Walla county, WA, was excluded from the sampling area because it is primarily a wind erosion area.

The survey covered only farm operators; persons who were landlords only were not interviewed. Others excluded from the population to be sampled:

- Operators with fewer than 10 acres of cropland in Alabama, Missouri, and Tennessee.
- Operators with fewer than 50 acres of cropland in Washington.
- Institutional and very large corporate farms in all counties.

Random samples were drawn from the reduced lists of farm operators in each sample county. The sample was randomly stratified by communities or subcounty districts in proportion to the total farm population in each community.

[4]Refer to "Basebook" for a more detailed discussion of the selection of the areas, sample design, and data collection procedures.

Samples of 90 farm operators were drawn in each of the counties (table 1). These sample sizes were large enough to say at the 95-percent confidence level that the samples would accurately represent the total farm populations from which they were drawn. This means that there would be only 1 chance in 20 that the sample means would not correctly represent the true population.

Data Obtained From SCS And ASCS

SCS provided additional data on the hours of technical assistance provided to each sample farm operator from 1981-83 (study period) and how this compared with the amount of assistance that was provided to the same farm operators over the 3 previous years (1978-80). This permitted comparisons of the ongoing base conservation program with the accelerated targeting program that started in 1981 for SCS. SCS also provided information on the severity of the erosion problem on cropland in 1980 (base year) on farm operators' owned and rented land. Thus, comparisons could be made between SCS measures of severity of erosion and farm operators' perceptions of severity on the same farms.

ASCS also provided data on the amount of cost-share funds by type of practice from 1980-83. This information permitted further comparisons of ongoing base cost-share conservation programs with the targeting program.

Table 1--Population and sampling frame for targeting survey, 1983

States and counties	Survey population		Sample(2)
	Original	Reduced(1)	
	Number		
Alabama:			
Barbour	759	569	87
Henry	408	306	90
Total	1,167	875	177
Missouri:			
Daviess	924	693	87
Harrison	1,097	823	88
Total	2,021	1,516	175
Tennessee:			
Dyer	966	724	87
Haywood	854	640	89
Total	1,820	1,364	176
Washington:			
Columbia	172	129	87
Walla Walla	150	112	94
Total	322	241	181
Grand total	5,330	3,996	709

(1) The original population was reduced because of the exclusion of farms with fewer than 10 acres of cropland in Alabama, Missouri and Tennessee and fewer than 50 acres in Washington. Institutional farms, people who no longer farm, and those that were landlords only were also excluded.

(2) This sample size provides a confidence level of 95 percent.

Note: Sampling procedure based on T. Yamane, Elementary Sampling Theory, Prentice Hall, Inc., 1967, pp. 99, 398.

Description Of Survey Areas

Barbour and Henry Counties, AL

Soils and Climate. Barbour and Henry counties, part of the Southern Coastal Plains Major Land Resource Area (MLRA), are characterized by red sandy loamy soils and low fertility. Rapid leaching of minerals and low water-holding capacities result in drought damage to crops. Rainfall averages 54 inches per year in the two counties, but 4-to 6-week droughts in the late growing season often occur. Intense rains are common, but the most damage to soils occurs during the early growing season and the post-harvest season when the soils are the least protected [24].

Continuous row cropping, straight row farming, little conservation tillage, and the above soil and rainfall conditions contributed to average annual cropland soil losses (sheet and rill) of 30 tons per year in Barbour and 19 tons in Henry in 1978.

Land Use. While 44 percent of the land area in Barbour county was in agricultural use, only 18 percent was in cropland. The proportions in Henry county were 54 and 29 percent. Peanuts, soybeans, and corn were the predominant crops.

Recommended Practices. No one practice or even a set of practices that applies to all farms is recommended for Barbour and Henry counties because individual fields and soils are unique. Rather, farmers, consulting with SCS, seek a package of practices most appropriate for specific problems. Major practices generally appropriate are terrace systems outletting onto grassed waterways or tile outlets along with either no-till or minimum-till farming. Structures such as diversions and sediment retention or erosion or water control structures are also effective. Establishing permanent vegetative cover on critical erosion areas is the primary means of controlling gully erosion.

Farm and Operator Characteristics. Twenty percent of the farms in both counties contained fewer than 50 acres each, much of it noncropland, according to the 1982 Census of Agriculture (table 2). Many were parttime operators. Average farm size was 378 total acres in Barbour and 410 acres in Henry. More full-owner operators were found in Barbour (71 percent) than Henry (44 percent). There were small percentages of tenants in both counties: 12 percent in Barbour and 15 percent in Henry county. Average age of farm operators was 52 years in Barbour and 51 years in Henry. Most farms were nonincorporated family operations.

Daviess and Harrison Counties, MO

Soils and Climate. These two counties lie in the Iowa and Missouri Heavy Till Plain MLRA where Shelby, Zook, Grundy, and Lamoni are the prevalent soils [30]. Although many cost-shared practices are available, 54 percent of the cropland in the area is farmed without conservation measures [33]. Erodibility of these soils is low to moderate. Average annual rate of upland sheet and rill erosion is 11 tons per acre. Straight row farming, conventional tillage methods, and an average annual rainfall of 36-37 inches contribute to the erosion problem. A drought in 1982 and a wet spring in 1983 limited farmers' ability to adopt many practices during the early part of the targeting program.

Land Use. Some 63 percent of the land in the area was in cropland. Principal crops are soybeans and corn, with some small grains used in rotation.

Recommended Practices. The set of conservation practices recommended for Daviess and Harrison counties is similar to those suggested for the two Alabama counties with a little more emphasis on terraces with tile outlets. No-till is also recommended.

Farm and Operator Characteristics. Most farm and operator characteristics in Daviess and Harrison counties were similar to the two Alabama counties (table 2). But, the numbers of farms in the Alabama counties were about half the numbers in the Missouri counties and the farms in the Alabama counties averaged about 10 to 20 percent larger.

Table 2--Selected farm and farm operator characteristics of survey targeted counties, 1982(1)

Characteristics	Unit	Survey targeted counties							
		Barbour AL	Henry AL	Daviess MO	Harrison MO	Dyer TN	Haywood TN	Columbia WA	Walla Walla WA
Farms:	No.	587	475	982	1,054	788	585	236	823
Average acres per farm	Ac.	378	410	304	367	345	381	1,453	909
Farms by size (acres):									
1-49	No.	110	85	163	135	212	168	41	390
50-499	No.	368	280	642	666	410	289	71	182
500-999	No.	66	60	119	177	102	65	42	70
1,000-1,999	No.	25	38	51	64	46	44	36	64
2,000 or more	No.	18	12	7	12	18	19	46	117
Farms by organization:									
Family	No.	524	389	867	901	669	510	180	633
Partnership	No.	51	72	94	117	108	66	28	89
Corporation	No.	9	8	21	33	9	5	23	94
Other	No.	3	6	--	3	2	4	5	7
Days worked off farm:									
Any	No.	317	240	455	450	380	242	98	370
100 and more	No.	259	210	328	316	321	189	76	308
Tenure of operator:									
Full owners	No.	356	210	564	558	347	267	110	419
Part owners	No.	161	193	311	340	289	247	85	271
Tenants	No.	70	72	107	156	152	71	41	133
Operators by age (years):									
Average age	Age	52	51	50	50	51	51	53	52
Less than 25	No.	16	7	52	59	20	20	2	9
25-44	No.	177	154	323	336	251	181	70	254
45-54	No.	126	103	183	205	170	121	45	178
55-64	No.	151	133	216	218	206	132	67	224
65+	No.	117	78	208	236	141	131	52	158
Farms by value of sales:									
($)Less than 5,000	No.	240	140	259	244	204	158	58	287
5,000-9,000	No.	80	43	146	168	97	83	15	90
10,000-19,999	No.	61	46	149	167	114	86	24	41
20,000-39,999	No.	67	61	189	181	119	66	20	55
40,000-99,999	No.	65	91	151	206	136	99	41	91
100,000-249,999	No.	56	66	73	81	90	62	46	127
250,000 and more	No.	18	28	15	7	28	31	32	132

(1) U.S. Department of Commerce, Bureau of the Census, Census of Agriculture Preliminary Report, 1982.

Dyer and Haywood Counties, TN

Soils and Climate. Dyer and Haywood counties lie in the Southern Mississippi Valley Silty Uplands MLRA. Predominate soils in the eastern two-thirds of Dyer and all of Haywood county are Memphis, Loring, and Grenada. These are upland loess soils on 3- to 6-percent slopes that are highly erodible [31]. Cropland erosion rates without conservation practices are 35-40 tons per acre annually. An average annual rainfall of 48 inches can be intense during the spring and fall. Recently shifting from cattle to row crops, farm operators have plowed up grassland and planted soybeans. Cropland comprised almost half of the total land area with soybeans being the major crop. Some corn and cotton are also grown.

Recommended Practices. Recommended conservation practices are similar to those suggested in the Alabama and Missouri counties. Terraces with tile outlets have been heavily emphasized. Although no-till is recommended as a general pratice, it has to be applied carefully to appropriate soils. Minimum or reduced tillage is perhaps recommended the most by conservation agencies (except for cotton). Permanent vegetative cover for critical areas and various types of structures are encouraged where appropriate.

Farm and Operator Characteristics. Average farm sizes were slightly larger than in the Missouri counties, but smaller than in the Alabama counties (table 2). Less than half of the operators in Dyer (44 percent) and Haywood (46 percent) counties were full owners, contrasting to over 50 percent in the Missouri and Alabama counties. Tenancy was higher in Dyer county (19 percent) than in Haywood county (12 percent). Average age of farm operators matched those of the other states. Fewer corporation farms were reported in Dyer and Haywood counties than in any of the counties.

Columbia and Walla Walla Counties, WA

The survey counties in Alabama, Missouri, and Tennessee are very similar in climate, land use, and farm and personal characteristics. But, the Washington counties differ significantly from those in the other three study states.

Soil and Climate. Columbia and Walla Walla counties are part of the Palouse area of eastern Washington. Although adjacent to each other, Columbia is mainly in the Northern Rocky Mountains MLRA while Walla Walla is mainly in the Columbia Plateau MLRA. However, soils in the eastern part of Walla Walla (the area surveyed) and in Columbia counties are of somewhat similar loessal and volcanic rock [32]. (Some Columbia and Walla Walla soils are in the same MLRA.) Slopes of 30 to 40 percent are often farmed, resulting in sheet, rill, and some gully erosion. The western part of Walla Walla county was omitted from this survey because it was not targeted.[5]

Land Use. While row cropping is the major pattern in the other survey counties, small grains, especially wheat, are the predominant crops in the Washington counties. Winter wheat, barley, and dry peas are the major crops; however, spring wheat, green peas, lentils, garbanzo beans, and bluegrass seed are also important.

[5]See "Basebook" for more details on selection of farm operator sample.

Recommended Practices. The Palouse area requires a unique set of practices and techniques to control erosion. Terraces without outlets, stubble mulching on fallow land, divided slope farming, and minimum-till are suggested practices for Columbia and Walla Walla counties.

Farm and Operator Characteristics. Average farm size in Columbia and Walla Walla counties was two to three times as large as those in the other counties (table 2). Columbia county had the smallest number of farms of all the survey counties while Walla Walla's 823 placed third behind the two Missouri counties. Columbia's distribution of farm size was about evenly divided. Almost half of the Walla Walla farms had fewer than 50 acres while 14 percent contained 2,000 or more.

About half of the Columbia and Walla Walla farm-operators were full owners and another 16 to 17 percent were tenants only.

The only similarities noted between the two Washington counties and the other survey counties were in the average age of farm operators and in the absence of farm corporations.

IV. FARMERS' VIEWS ON CONSERVATION ISSUES

Few of the farm operators in any of the survey counties rated the overall erosion problem in their county as being very serious. However, the great majority rated soil erosion to be a moderate to serious problem: 79 percent in Alabama, 91 percent in Missouri, 86 percent in Tennessee, and 80 percent in Washington ("Basebook" table 135). When asked specifically about the loss of top soil, 78 percent in Alabama, 84 percent in Missouri, 85 percent in Tennessee, and 74 percent in Washington rated it as a serious to very serious problem ("Basebook" table 136). Thus, farm operators' perceptions of county erosion problems would appear to be a favorable factor influencing adoption.

Farm operators were less critical of their own erosion problems. Sixty-nine percent reported that none of their land had a serious erosion problem, while SCS indicated that only 46 percent of farmers should be able to classify all of their owned cropland as having no serious problem ("Basebook" tables 123 and 124). Thus, there was a difference of opinion between the operator and SCS about soil erosion on individual farms.

Farm operators were generally more concerned about soil erosion in 1983 than they were in 1980 before targeting began. This was true for all eight survey counties but especially so in Alabama, Tennessee, and Washington ("Basebook" table 144). Over two-thirds of farm operators in the survey counties in Alabama, Missouri, and Washington indicated they were critical of other farmers who do not follow erosion control practices ("Basebook" table 146). But, less than a fourth of Tennessee farmers (and half of Haywood county operators) said they were critical of those who did not follow erosion practices.

V. FARMERS' ADOPTION OF EROSION CONTROL PRACTICES

Many farmers still did not follow recommended erosion control practices in 1980 despite many years of conservation efforts by federal agencies and others. The targeting program aimed to speed up the adoption through increased SCS technical assistance and ASCS cost-sharing in the targeted areas.

The effect of the targeting program is indicated in the following analysis of farmers' adoption of erosion control practices.

Farm operators' use of erosion control practices on owned and rented cropland was measured in 1980 (pretargeting) and in 1983, since a primary objective of the targeting program was to accelerate the application of conservation treatment in critical erosion areas.

Levels Of Practice Adoption, 1980-83

At least one erosion control practice was being applied on 86 percent of owned cropland by surveyed farmers in Alabama and Missouri during 1980 (table 3). The comparable figure for Washington was 83 percent, while Tennessee's was much lower at 52 percent. Rented cropland received less treatment, especially in Missouri (table 3).

By 1983, after 3 years of the targeting program, the percentage of owned land upon which at least one erosion control practice was being applied increased in each state (table 3). And, the percentage gap between owned and rented land was narrowed substantially during 1980-83, except in Missouri (table 3). These data, while indicating a general increase in conservation practices between 1980 and 1983, do not necessarily indicate adequately treated acres. Moreover, the data do not imply farm operators who both owned and rented land necessarily treated their owned land better than their rented land. But, total owned cropland in the sample counties probably contained more acres in treatment than did the total rented land, according to the data.

The greatest percentage of cropland with terraces in 1980 on owned land was found in Alabama, with substantially less in Tennessee, Missouri, and Washington (table 4). Rented land lagged behind owned land in the percentage of

Table 3--Proportion of farms upon which at least one conservation practice was being used, owned and rented land

State/tenure status	Percentage of farms reporting the use of at least one conservation practice		
	1980	1983	Change, 1980-83
	Percent		
Alabama:			
Owned land	86	91	6
Rented land	75	86	15
Missouri:			
Owned land	86	94	9
Rented land	66	71	8
Tennessee:			
Owned land	52	72	38
Rented land	46	69	50
Washington:			
Owned land	83	89	7
Rented land	79	89	13
Total:			
Owned land	77	86	12
Rented land	66	81	23

cropland acres in terraces, except in the Washington counties where the percentage was low on both owned and rented land in 1980. Modest increases were found on owned and rented land by 1983, except again Washington which remained unchanged.

Diversions and other structures remained relatively low and unchanged in Alabama and Missouri (table 4). Tennessee experienced some increased use of these practices. These practices were not applicable in the Washington sample counties.

Table 4--Percentages of cropland and changes in erosion control practices

Practice	Alabama			Missouri			Tennessee			Washington			Average		
	1980	1983	Change	1980	1983	Change	1980	1983	Change	1980	1983	Change	1980	1983	Change
	Percent														
Terraces(1):															
Owned land	41	46	12	16	23	44	18	23	28	5	5	0	14	16	14
Rented land	23	29	26	9	13	44	13	23	77	5	5	0	10	13	30
Diversions and other structures(2):															
Owned land	10	12	20	5	7	40	12	26	117	0	0	0	4	7	75
Rented land	3	3	0	3	4	33	10	22	120	0	0	0	3	6	100
Conservation tillage(3):															
Owned land	19	28	47	31	49	58	5	10	100	63	84	33	42	59	40
Rented land	13	18	38	35	51	46	3	4	33	46	70	52	30	46	53
Other erosion control practices(4):															
Owned land	6	9	50	20	20	0	3	5	67	12	20	67	11	16	45
Rented land	2	3	50	9	10	11	1	2	100	20	26	30	12	15	25
Total erosion control practices(5):															
Owned land	76	95	25	72	99	38	38	64	68	80	109	36	71	98	38
Rented land	41	53	29	56	78	39	27	51	89	71	101	42	55	80	45

(1) Includes terraces outletting onto grassed waterways in all states; terraces with underground outlets in Alabama, Missouri, and Tennessee; and terraces without outlets in Washington.

(2) Includes diversions, sediment retention, erosion or water control structures.

(3) Includes no-till, minimum or reduced tillage, and, in the case of Washington, stubble mulching on fallow land.

(4) Includes establishing permanent vegetative cover and grassed waterways alone (not part of a terrace system) in all states and divided slope farming in Washington.

(5) Percentages can add to more than 100 percent of the cropland, since farmers frequently apply more than one practice on the same field.

Most of the acreage increase in erosion control practices occurred with conservation tillage (minimum or reduced tillage and no-till farming). Even though Washington had the highest percentage of cropland acres in conservation tillage on both owned land and rented land in 1980, the sample counties in Washington also experienced the largest increase in its use by 1983. Missouri, Alabama, and Tennessee trailed in that order.

Other erosion control practices included establishing permanent vegetative cover and grassed waterways in Missouri, and divided slope farming and stubble mulching on fallow land unique to the Palouse area.

Plans To Increase Use Of Practices

Most farm operators planned to increase the use of conservation practices within the next 2 years from the point of the survey (November 1983 to February 1984). For example, 105 of 177 farm operators in Alabama planned to increase one or more practices in the next 2 years and 58 percent of the increases would be terraces (table 5).

Table 5--Conservation practices farm operators plan to increase in 1984 and 1985

Practice	Alabama	Missouri	Tennessee	Washington	Average
			Percent		
Terraces (1)	58	63	44	5	42
Diversions structures (2)	14	16	42	1	18
Conservation tillage (3)	9	10	3	42	16
Other erosion control practices (4)	20	9	12	52	24
Total erosion control practices (5)	101	98	101	100	100
			Number		
	105	97	101	106	409
	[177] (6)	[175]	[176]	[181]	[709]

(1) Includes terraces outletting onto grassed waterways in all states; terraces with underground outlets in Alabama, Missouri, and Tennessee; and terraces without outlets in Washington.
(2) Includes diversions, sediment retention, erosion or water control structures.
(3) Includes no-till, minimum or reduced tillage, and, in the case of Washington, stubble mulching on fallow land.
(4) Includes establishing permanent vegetative cover and grassed waterways alone (not part of a terrace system) in all states and divided slope farming in Washington.
(5) Percentages can add to more than 100 percent of the cropland, since farmers frequently apply more than one practice on the same field.
(6) Number in brackets refer to total sample farm operators in each state.

A similar pattern was observed in Missouri. In Tennessee, 101 farm operators of the 176 sampled planned to increase practices, but diversions/structures as well as terraces were the major planned practices. The pattern observed in Washington was quite different. Most of the planned increases were in conservation tillage and in other erosion control practices, primarily divided slope farming and stubble mulching on fallow land.

The main reason Alabama, Tennessee, and Washington farmers gave for planned increases in conservation practices was to save soil (table 6). In contrast, expected cost-sharing was the major reason in Missouri. Cost-sharing was the second most important reason in Alabama and Tennessee. These reasons were expected since terraces and diversions/structures were the practices that most operators were planning to increase in the next 2 years in Alabama, Missouri, and and Tennessee. In Washington, where nonstructural practices were the most common practices, cost-sharing was a minor factor because it was generally not applicable to these practices.

Table 6--Farm operators' reasons for planned practice increases

Reasons for planned increases	Alabama	Missouri	Tennessee	Washington	Total
			Percent		
To save soil	52	32	60	46	45
Expects benefits to exceed costs of practices	19	5	20	24	19
Expects to receive cost-sharing	24	64	20	8	21
Other reasons	5	0	0	22	15
Total	100	100	100	100	100
			Number(1)		
Total	21	22	5	76	124
			Number(2)		
	[105]	[97]	[101]	[106]	[409]

(1) Number of farm operators who gave reasons for planned increases.
(2) Number of farm operators who plan to increase practices.

Farm Operator And SCS Opinions On Use Of Conservation Practices

Perceptions of farm operators and SCS personnel concerning the use of appropriate conservation practices on sample farms differed markedly (table 7). Overall, 44 percent of the farm operators thought they were using most or all of the available practices, compared with SCS' 17-percent perception in 1983. Only 13 percent of

farmers thought they were using either few or none of the recommended conservation practices on their farms. In sharp contrast, SCS personnel estimated that 40 percent of farmers were using few or none of the recommended conservation practices. Differences in judgments were most pronounced in Alabama and least so in Tennessee.

Table 7--Perceptions of farm operators' use of available erosion control practices

Using available practices	Alabama		Missouri		Tennessee		Washington		Total	
	Farm operator	SCS	Farm operator	SCS	Farm operator	SCS	Farm operator	SCS	Farm operator	SCS
					Percent					
None	5	0	4	9	9	39	3	3	5	11
Few	11	31	5	28	13	30	4	26	8	29
Some	27	47	49	40	47	26	49	54	43	43
Most	44	22	36	20	26	5	40	17	37	16
All	13	0	6	3	5	0	4	0	7	1
Total	100	100	100	100	100	100	100	100	100	100
					Number					
Total	177	174	175	109	176	132	181	167	709	582

Number missing or not applicable cases was zero for farm operators and 127 for SCS.

Inclination to Adopt

The 1980-83 change in farmers' attitudes toward adoption of erosion control practices indicates the impact of targeting. Fifty-six of the sampled farmers said they were more inclined to adopt erosion control practices in 1983 than in 1980 (table 8). The most pronounced increases in inclination to adopt conserving practices were in Alabama and Missouri, but Tennessee and Washington followed closely. Targeting was likely instrumental in effecting this substantial change, but other factors were probably also important, e.g. conservation tillage practices lower costs and raise net returns.

Table 8--Farm operators' inclinations to adopt erosion control practices in 1983 compared with 1980

Inclination to adopt practices in 1983	Alabama	Missouri	Tennessee	Washington	Total
			Percent		
Much less inclined	1	2	0	2	1
Slightly less inclined	3	0	2	1	1
About the same	34	40	43	48	42
Slightly more inclined	20	26	30	20	24
Much more inclined	42	32	25	29	32
Total	100	100	100	100	100
			Number		
Total	177	174	175	181	707

VI. FACTORS AFFECTING ADOPTION OF EROSION CONTROL PRACTICES

This report primarily examines factors appearing to affect adoption of soil erosion control practices. Practices adopted by sample farmers were viewed by this study as dependent on a series of causal factors (independent variables) both internal and external to the farmers' operations. The adoption decision was assumed to be the result of the combined influence of a number of variables of varying importance (see conceptual model, figure 1). The adoption process is affected by a series of variables that can be either conflicting or reinforcing, and that can have differing effects, depending upon factors outside the modeling process.

Each state was considered a separate sample area in the following analysis. Rather than combining the data from the four states into a single "national" data set, the study ran the statistical models four times for each series of tests or dependent variables, once for each state-level sample. Counties within the states were assumed to be sufficiently alike to warrant combining counties into state-level samples. The decision to treat each of the four states as separate survey areas was justified because the inclusion of these states was intended as a means of representing the major soil erosion problem areas in the United States. This approach permitted separate state-level analyses and also comparisons of similarities and differences among the various state models.

A problem presented by the data set involved the large numbers of independent variables available for analyses. The survey instrument provided responses to

many more independent and dependent variables than could be acceptably modeled. Criteria for variable inclusion considered relevant theory, previous empirical results, and the ability to measure the factors involved. In addition, the usefulness of a variable to SCS and ASCS policy formulation was considered. These same criteria provided the basis for selecting independent and dependent variables discussed below. The elimination of variable redundancy or the likelihood that an intercorrelation among variables might surface and cause interpretation problems provided additional criteria for variable limitation. Finally, the distribution and validity of responses collected for a variable were scrutinized. Variables with poor response rates and/or limited response ranges or distributions were replaced or eliminated. The following two sections define the sets of dependent and independent variables that met all the criteria established for inclusion in the statistical analysis of the factors affecting adoption.

Dependent Variables

The literature on the factors affecting adoption of erosion control has provided a multitude of measures representing adoption as a dependent variable. These measures have been both quantitative and qualitative and have included variables measured continuously, categorically, and binomially. At times, adoption has been viewed as either a discrete or continuous choice event by previous researchers. Varying research objectives will, of course, provide some cause for the different representations of adoption, as will limitations in the data available for testing.

Weighted indexes, ratio measures, categorical groupings, binomial measures, and percentage change variables were considered. However, it was decided to narrow the choices to those versions that would be continuous-level measurements and readily adaptable to regression analysis.

The four dependent variables selected include the following:[6]

- o 1983 level of practice adoption, expressed as a percentage of the farm under conservation.
- o 1980-83 change in practice adoption, again expressed as a percentage measure.
- o 1983 number of practices utilized for the first time by the farm operator.
- o 1980-83 change in farmers' inclinations to adopt erosion control practices.

Each of the first three measures summed across all surveyed practices for each farm, with owned land separated from rented land. The first two measures of adoption were also repeated for two separate practices: terraces with grassed waterways and minimum tillage. The final measure was tested for the entire farm unit without separation of land into tenure types.[7]

[6]There exists one exception to this decision. A variable that was essentially categorical and measuring inclinations towards adoption was retained.

[7]A detailed description of the variables used in the statistical analysis appears in the Appendix.

Independent Variables

Discussion of the regression analyses relating various factors to adoption of soil erosion control practices follows. The detailed statistical indicators of these relationships are shown in tables 9 and 10.

A total of 27 independent variables were specified for inclusion in the final model used in the analysis of factors affecting adoption. Not all of these variables were included in any single model (see Appendix for detailed description). The 27 variables considered represent the best mix of variables available with respect to explanatory efficacy, given the limitations of the data and the criteria mentioned earlier. They are:

A. Personal Factors

1. Years operating farm
2. Education
3. Management ability
4. Degree of agrarianism
5. Future farm ownership plans
6. Risk attitudes
7. Perception of erosion

B. Business Factors

1. Gross farm income
2. Debt per acre
3. Debt/asset ratio
4. Percent of income from crops
5. Income time frame

C. Farm Physical Factors

1. Acres in farm
2. Percent of farm in row crops
3. 1980 conservation effort
4. Erosion severity index

D. Tenure And Organizational Factors

1. Partial owner/partial renter
2. Rental agreement
3. Landlord-tenant cost-sharing
4. Years expecting to rent
5. Number of landlords
6. Partnership

E. Participation Factors

1. SCS participation score
2. Delivery system assistance

Table 9--Statistical relationships between dependent and independent variables, owned land, by state

Independent variables	Dependent variables											
	1983 level of conservation				Change in conservation				Number of conservation practices used for first time			
	AL	MO	TN	WA	AL	MO	TN	WA	AL	MO	TN	WA
A Personal factors:												
1 Years operating farm				++		--				-		
2 Education										++		++
3 Management ability			++		++							
4 Degree of agrarianism				+					++			
5 Future farm ownership plans		+	++	++		++		-				
6 Risk attitudes			++			++	++					
7 Perception of erosion			++					+				+
B Business factors:												
1 Gross farm income	-	++			--							
2 Debt per acre	--		++			-	++			-	++	
3 Debt/asset ratio												
4 Percent of income from crops	--											
5 Income time frame	--		++	+			++	++	--	+		++
C Farm physical factors:												
1 Acres in farm				+					+	++		
2 Percent of farm in row crops				NA				NA			--	NA
3 1980 conservation effort	NA	NA	NA	NA	--	--		--	--	--	--	--
4 Erosion severity index												++
D Tenure and organizational factors:												
1 Partial owner/partial renter	--	--	--	--	--	--		--		--		
2 Rental agreement	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3 Landlord-tenant cost-sharing	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4 Years expecting to rent	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5 Number of landlords	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6 Partnership								-				+
E Participation factors:												
1 SCS Participation score	++	+	++			++			++	++	++	++
2 Delivery system assistance	+				++	+				++		
F Other factors:												
1 Off-farm work by farmer							++					-
2 Off-farm work by spouse	--					++						--
3 Peer pressure												+

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variables.

A - sign means a negative statistically significant relationship between the dependent and independent variables.

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

Table 10--Statistical relationships between dependent and independent variables, rented land, by state

Independent variables	Dependent variables											
	1983 level of conservation				Change in conservation				Number of conservation practices used for first time			
	AL	MO	TN	WA	AL	MO	TN	WA	AL	MO	TN	WA
A Personal factors:												
1 Years operating farm								-			+	
2 Education					+				++	++		++
3 Management ability				--	+							--
4 Degree of agrarianism							++				++	
5 Future farm ownership plans	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6 Risk attitudes										-		
7 Perception of erosion					++						--	
B Business factors:												
1 Gross farm income					--				--	++		
2 Debt per acre												
3 Debt/asset ratio		++										-
4 Percent of income from crops		--					++					
5 Income time frame				--								
C Farm physical factors:												
1 Acres in farm							++			++		-
2 Percent of farm in row crops		+		NA	++			NA				NA
3 1980 conservation effort	NA	NA	NA	NA	--			--	--		--	--
4 Erosion severity index							+					++
D Tenure and organizational factors:												
1 Partial owner/partial renter	--	--		--	--				--			
2 Rental agreement		++	++						+			
3 Landlord-tenant cost-sharing		+		+				++			++	++
4 Years expecting to rent								-	+			--
5 Number of landlords	++		--	++								
6 Partnership		-		--		-				-		
E Participation factors:												
1 SCS Participation score			++							++	++	
2 Delivery system assistance			++	++				++				
F Other factors:												
1 Off-farm work by farmer	-			--	--		++			--		
2 Off-farm work by spouse												
3 Peer pressure			++		++						++	

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variables.

A - sign means a negative statistically significant relationship between the dependent and independent variables.

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

F. Other Factors

1. Off-farm work by farmer
2. Off-farm work by spouse
3. Peer pressure

Personal Factors

Personal variables, measuring some individual aspect about the farm operator, include years operating the farm, education, management ability, farm orientation (agrarianism), future farm ownership plans, and perceptions of the erosion problem.

The number of years operating the farm is a proxy variable for age. To the extent that this variable represents age as a factor, it would have an expected negative influence on changes in conservation behavior and a positive influence on the level of conservation achieved. However, the data show that years operating the farm had only spotty influences.

The number of years operating the farm indicated a negative influence on owned land changes in conservation and the number of practices used for the first time in Missouri. However, this variable was not significant for owned land in any of the other states. For rented land in Washington, this independent variable had a negative influence on the overall change in conservation, while in Tennessee the negative impact was on the number of first-time adoptions. For both Washington and Tennessee, these results are based on significance levels greater than 10 percent, but suggest that it was the newer renters who made the changes. The older renters could have had no need to do any further erosion control due to past efforts or even farming land of better quality (less erodibility). The newer renter might also have been facing land of poorer quality than the older renter.

The number of years farmed had statistically significant impacts on the 1983 level of adoption for only Washington, and that for owned land only. A positive impact for this proxy variable for age simply indicates that the longer one controls the farm the more opportunity one has to implement conservation measures. Moreover, the 1983 level of conservation dependent variable addresses cumulative behavior and is not a measure of change. On the other hand, the negative relation to change indicates either a reluctance to try new ways or quite possibly a diminished need to adopt controls due to previous efforts.

The cross-state and cross-dependent variable comparisons for this variable exhibited a pattern generally repeated for the remaining independent variables. Each state appeared to act independently of the others, and each dependent variable measured distinctly different behavior. At no time did Alabama exhibit any significant relation to the years farmed while Missouri showed no impact on rented land. Tennessee showed an impact for rented land for only one dependent variable and Washington showed an impact for rented land in one instance and owned land in another. Generalizations across states or dependent variables are extremely limited.

Education was expected to have a positive influence on all measures of adoption behavior; but, as indicated, it was most significant for the number of practices used for the first time. The number of practices used may be more a measure of sophistication or complexity, and education would play a key role in the ability to handle and/or evaluate such complexities. Only in Alabama did education

influence overall changes in adoption and this is for rented land. Education appeared to have no relation to the level of adoption for any state or land tenure type. Education appeared to affect change only, and generally more often for rented than owned land.

In Washington and Missouri, education remained important for both owned and rented land adoptions, but was important for only rented land in Alabama. Education did not appear to be a significant causal variable. Washington and Missouri had the largest number of respondents with high school or higher educations (93 and 84 percent, respectively), while Tennessee had the lowest (67 percent). The relatively more numerous significances on rented land may also indicate the fact that newer, generally younger and more formally educated farmers tended to operate more rented than owned land.

A somewhat related variable to education is management ability. This variable combines years farmed, education, use of consultants or outside sources of information, and the use of a computer. This index variable was expected to be a positive influence on all measures of adoption and thought to be a more broadly based measure of knowledge and the ability to use information and experience.

The results, however, indicate mixed signals and a limited degree of significance for this measure of abilities. Management ability in Washington exhibited a negative influence on the level of adoption on owned land and the number of practices used for the first time on rented land. In contrast, the effect was positive in Alabama on both owned and rented land for overall changes in conservation and positive in Tennessee for the 1983 level of conservation use. This variable had no significant effect on adoption in Missouri.

It is not obvious why the effect of management ability in Washington should be negative or that the results appeared spotty in cross comparisons. This is another example where states did not agree. But, since this variable is a composite of several other variables, it is difficult to decompose in order to trace the direction of relationships. It may be that this management measure was not the best available for each state and perhaps more state-specific measures need to be constructed. The results for this variable might be best considered as tentative.

Closely related to education and management abilities are perceptions of the erosion problem. Perception was specified as an index variable; perceptions of greater erosion severity would be expected to encourage adoption. It could be expected that this variable might affect change measures more frequently than cumulative measures of adoption behavior.

Perceptions of the erosion problem seemed somewhat important in Washington on owned land for both measures of change in adoption, showing a positive impact at an 11- to 15-percent significance level. Alabama had some limited agreement with Washington, but the positive impact was on rented land for the overall measure of change in adoption behavior. This variable had no importance in Missouri and had contradictory results in Tennessee. In Tennessee, this variable had positive significance for the level of adoption on owned land but negative significance for number of practices used for the first time on rented land. Such results as those for Tennessee further indicated the importance of the choice of the dependent variable in the analyses of erosion control adoption.

Future farm ownership plans, a variable testing for stewardship notions, refers to the farm operator's intention to pass the farm to another family member upon

retirement. This variable pertains to owned land only. The data generally show that stewardship has a positive influence on the level of adoption, but only in Missouri did it have positive impact on change. One surveyed farmer in Missouri believed that quite a few of the area's operators were nearing retirement and beginning to get their lands in shape to pass down to their sons. To the extent that this impression is true for the sample area in Missouri, a positive relation between change and stewardship seems plausible. But, this variable is generally more relevant as a variable affecting the cumulative level of adoption and not the period-to-period change in that level (unless the periods specify a sufficiently long timeframe). It is surprising, though, that future farm ownership plans exhibit a negative impact on adoption in the single case of Washington.

Washington appears to be a special case in which the future farm ownership plans variable measured something other than what was intended. The negative impact of intentions to pass the farm along to family on the change dependent variable can make sense if the respondents were mostly older with a good deal of erosion control already accomplished, or if they had land with little or no erosion problems. The positive impact of the years farmed variable for the level of conservation appears to support this partial interpretation.

The degree of agrarianism is intended to assess the farmer's view of farming as a way of life or as a business. Positive associations between this and the dependent variables indicate a more business-oriented approach is less conducive to adoption while a more philosophical approach fosters erosion control.

However, agrarianism did not appear to be a broadly applicable causal variable; it was significant in only 4 of the possible 24 tests. Agrarianism showed the most importance in Tennessee for rented land tests with both measures of change. It was also significant on owned land in Alabama for the number of practices used for the first time and was only marginally important on owned land in Washington for the level of adoption achieved. This variable had an overall marginal importance across states, dependent variables, and land tenure types. Even when significant, agrarianism tended to have relatively less importance than the other significant variables in the model. Yet, in Tennessee, this variable was important for rented land changes and it might be wrong to exclude its influence.

The risk index variable is another possibly unimportant factor in the adoption process. Risk was significant in only four tests with one of these being a marginally negative result. The positive sign for this variable in Missouri and Tennessee indicated that adoption was associated with more risktaking. This is the expected result; however, risk appeared to have no significant effects on rented land behavior at better than a 10-percent level, but it did affect the number of practices used for the first time in Missouri at a 13-percent significance level. Risk appeared to have its most significant effects on owned land and tended to be more important for changes in overall adoption.

The general nonsignificance of risk factors in the adoption process is puzzling. Previous research has shown this to be an important component in the decision process. Those farmers more prone to avoid risk are thought to be those most likely to adopt erosion control. Although the results here do not refute this possibility, the statistical support is rather limited and certainly a function of the type of adoption and the state studied.

Business Factors

Business factors include gross income, debt level, debt-asset ratio, percentage of income from crops, and income timeframe. All these variables were originally measured categorically and the values used in the model testings were converted to median values implied by the category ranges. (Details of these measurements are shown in the Appendix).

Income timeframe measures the timeframe of a farm operator's income concerns. Shortrun concerns are expected to constrain adoption. Longer term viewpoints are thought to positively affect adoption. Results, however, are mixed.

Timeframe appeared to be a more important issue on owned land, but was not entirely restricted from some rented land relationships. In Alabama, the direction of impact was negative for the level of adoption achieved and the number of practices adopted for the first time. This variable provided mixed impacts in Washington with the effect on rented land showing as negative for the level of adoption achieved, but then a positive for all measures of adoption for this state on owned land. The Tennessee results indicated a positive impact for overall level and change, but no significance outside of owned land or for the number of practices first used.

The mixed findings make it difficult to generalize the results for this variable. The impact was variable and a bit contradictory. Certainly, results for a single state or for rented land tests cannot be applied to other states or owned land considerations. Further research on this variable is needed for more conclusive results.

Gross farm income also provides somewhat mixed or conflicting results. In Alabama, larger farm incomes had significant dampening effects on the overall change in adoption on both owned and rented land. It was also negative for the number of practices first used on rented land and had marginally negative significance for the level of adoption on owned land in Alabama. Missouri is the only other state where gross farm income was statistically significant, but the effect was opposite of Alabama's. In Missouri, larger gross farm incomes induced higher levels of adoption on owned land and more first time adoptions on rented land.

The difference between Missouri and Alabama illustrates the divergence in the literature over the expected impact of gross income on adoption. Results here suggest that the divergence is well founded. The results also point out that even the impact within a state cannot be expected to be universally applicable.

Debt has been measured as an independent variable in two ways. Debt per acre measures the absolute level of debt per acre of farm operation. Debt-asset ratio measures the level of debt as a proportion of the level of accumulated asset. Less adoption is expected to occur for higher levels of debt or larger ratios.

The level of debt per acre repeated some of the pattern established in the results for gross farm income. Tennessee was clearly affected more frequently than the other states and the direction of impact was opposite that of the other states. In Tennessee, higher level of debt per acre was associated with more conservation adoption whereas in Missouri and Alabama the opposite was true.

The debt level was not significant in any test of rented land adoptions and was equally nonsignificant in all tests in Washington. The debt per acre variable

had only a marginal significance level when it exhibited negative impacts but was much more significant when positive in direction.

The positive sign for debt per acre is unexpected and can indicate a correlation rather than a causal phenomenon, though this is not certain. In Tennessee, the adoption of practices may have induced the higher debt level. On the other hand, higher debt level could have induced some conservation adoption behavior through a search for cost cutting production techniques. Minimum or reduced tillage aside from being a conservation practice, can under some circumstances reduce the planting costs. To the extent that minimum tillage reduces costs, it provides an economic rationale for adoption.

The debt-asset ratio was almost universally nonsignificant. In only one test did this variable provide better than a 10-percent level of significance. In Missouri, for rented land levels of adoption, the debt-asset ratio provided a positive influence on behavior at a 4-percent level of significance. The only other result for this variable was a 12-percent significance level in Washington for the number of practices used for the first time.

The percent of farm income from crops had more effect than the debt-asset ratio, but retained significance for only 3 of the 24 tests. Larger proportionate incomes from crops would be expected to constrain the options farmers face and induce less adoption behavior. This expected result proved true in Alabama for owned land and in Missouri for rented land for the level of adoption achieved. However, on rented land in Tennessee, proportionately larger incomes from crops induced larger changes in overall adoption behavior.

Aside from income time frame or farm income, the business factors tested appeared to have little overall impact on adoption behavior. But, the results are such that comparisons between states or even within states for differing land types or dependent variables are difficult. Adoption appeared to behave on a state-specific and land-type-specific level, with the direction or significance of a variable's impact also dependent on the measure of adoption tested.

Farm Physical Factors

These variables include farm size (in acres), the percentage of the farm in row crops, the weighted erosion severity index, and the 1980 base conservation level.

Farm size played only a weakly significant role in adoption when the dependent variable is measured as the level of adoption achieved. Except for owned land in Washington, cumulative levels of adoption appeared immune from size effects. But change, and especially the number of practices tried for the first time, had generally strong positive relationships with the numbers of acres farmed. These results are somewhat similar to those for education. Farm size and education may indicate an ability to handle several types of erosion control at once, both technically and financially.

Farm size, however, does not necessarily measure the same effect as does farm income. Taken together, both measures of relative size have clear effects on adoption, but the direction of their influence is generally not the same, nor do the types of adoption they affect match. Farm income had mixed positive and negative impacts. Farm size in acres influenced adoption negatively only once and in that case at a marginal level (Washington for the number of first time adoptions on rented land). However, farm income was more often a negative factor in adoption. Farm size in acres was most often important in Missouri and, as true

for farm income in Missouri, the effect was positive, although for farm size the impact was confined to the number of first-time adoptions on both owned and rented land. Acreage did not appear to affect the level of adoption on rented land or the change in the level of adoption on owned land for any state tested. Further, farm size had only a very marginal effect on the level of adoption on owned land. Size appeared to generally influence changes in adoption behavior more readily than it affected levels of adoption achieved.

The base conservation efforts variable was designed to measure previous conservation activity. It was expected that, the more conservation practiced prior to 1980, the less need there would be for changes in adoption from 1980-83. Up to a certain level, previous adoption behavior could be expected to increase the amount of change taking place through a learning effect. But the overall effect is expected to be negative for larger levels of prior adoption.

Base conservation was clearly a negative influence on changes in adoption behavior for all states and for all tests in Alabama and Washington. In Missouri, this variable was not significant for rented land changes nor was it significant for the level of change on rented and owned land in Tennessee. Some of the reasons for a lack of change in adoption for the period studied derived from previous successful conservation efforts.

The weighted erosion severity index measures, in a relative ranking, the proportion of an operator's land rated as severely erodible, moderately erodible, or having no erosion problems. Separate indexes were constructed for owned and rented land. It would be expected, from the way in which the question was worded, that this variable would have more of a relation to changes in adoption than to the level of adoption achieved.

The results indicate only a limited level of importance for the erosion severity index. In Washington, for the number of first-time adoptions, the amount of land rated as severely to moderately erodible provided a significant positive impact on both owned and rented land. In Washington, the farmer's self appraisal of the land's condition proved a beneficial impetus to change. But, this variable was not significant in overall levels of adoption in Washington.

The row crops variable exhibited a significant negative effect in Tennessee for the number of first time adoptions on owned land. In contrast, it was significantly positive in Alabama for changes in the level of rented land adoptions. In Missouri, this variable had a marginally positive impact on the level of adoption achieved on rented land. Overall, though, this variable had negligible effects on adoption behavior and in Missouri and Alabama appeared to be measuring something other than that hypothesized.[8]

Tenure And Organizational Factors

Variables included are partial owner/partial renter, type of rental agreement, landlord cost-sharing, number of landlords, and number of years expecting to rent. All these variables deal with some aspect of tenure, but only the first one was applied equally to owned and rented tests.

[8]It is doubtful that row cropping measured cash crop income since in Alabama the gross income variable indicated a negative impact for the same test.

The primary tenure variable measured the existence of both owned and rented land in the farm operation. In applications on owned land, this variable contrasts those owning all the land they operate with those also operating rented land. In applications on rented land, the contrast is between those renting all the land they operate and those also owning some of the land they operate. Negative relationships indicate that those controlling both owned and rented land are less inclined to adopt conservation measures.

This tenure variable was more often significant for owned land applications and for the dependent variables measuring the level of adoption achieved and the change in the level of conservation. This tenure variable had comparatively less impact on the number of first time adoptions. It was also more often significant in Alabama and Missouri than in Washington or Tennessee.

The most important factor determining the level of adoption on owned or rented land was, in most cases, the tenure status of the farmer (whether a full or partial owner or a full or partial renter) in most cases. Being both a renter and an owner apparently exerted significant negative influence on adoption behavior. In the discussion of independent variables, this variable was correlated with debt, age, and percent of gross income from crops; in Alabama, it was also strongly related to debt-asset ratios. Analysis indicated that the farmers operating both owned and rented land tended to be younger, derived more income from crops, and were perhaps those most constrained by debt.

The fact that tenure is negatively related to the level of conservation is not surprising given this variable's correlation to the age of the farmer. Younger farmers have not had as much time to accumulate land as have older farmers. Further, the diminished importance of this variable for rented land change is not surprising either, given the fact that all renters would appear to implement less erosion control than owners. There is hardly a difference between full renters and partial renters in the treatment of rented land since this land generally received much fewer changes in treatment during the study period.

However, the impact of the tenure variable for owned land changes (and rented land changes in Alabama) was significant and important. Aside from Tennessee, those managing owned and rented land were much less likely to add to the level of conservation in place. Yet, in Tennessee, there appeared no relation between changes in behavior and the management of owned and rented land. In Washington, changes in the level of adoption on owned land were negatively affected while in Missouri this was true for both measures of change. In Alabama, changes in adoption levels and the number of first time adoptions are significantly affected for rented land.

Overall, this variable appeared to be as important as base conservation efforts for changes in the level of conservation behavior; it may be the most important (negative) indicator of the level of adoption.

A written rental agreement was expected to provide a positive influence on adoption. The results do not contradict this expectation, but in only 2 of the possible 12 tests is the result statistically significant at a 10-percent level.[9]

Written rental agreements appeared to be strong determinants of the level of adoption achieved in Missouri and Tennessee. This variable did not appear to

[9]Only rented land tests are valid for this variable.

have an impact on changes in the level of conservation and was only marginally significant for one state for the number of practices first used.

Landlord-tenant cost-sharing on erosion control was expected to positively affect adoption. The sharing of costs allows the tenant to more rapidly gain a return for the investment in conservation or at least limit production costs.

Cost-sharing was quite important in Washington for all three measures of adoption. The variable was also significant in Tennessee for the number of first time adoptions and marginally important in Missouri for the level of adoption achieved. In all cases, results indicated a clear positive impact. But, the effect was not true for all states or even for all dependent variables, aside from Washington.

The number of landlords variable affects the level of adoption only. It had no effect on change, but was positively related to the level of adoption in Alabama and Washington and negatively related in Tennessee. For Washington and Alabama, the number of landlords variable may be somewhat of a limited measure of size. More landlords most likely means more land operated, at least to a certain extent. However, given the general nonimportance of farm size and gross farm income, it is not clear whether the number of landlords can represent a size measure. The result for Tennessee, however, is more likely than expected. Additional landlords should add complexities to the farm management process and especially to the decisions regarding types and extent of conservation; this appears true for one case in Tennessee.

An additional tenure variable measures the number of years the tenant expected to continue renting. Longer expectations might induce conservation behavior through the provision of lease stability. Longer term activities allow the tenant to reap full advantage of the conservation effort. However, the results indicated both mixed levels of significance and limited applicability. In only one case did the result prove significant, and the impact in this instance was opposite that expected.

The two tenure-related variables, just discussed, suggest conflicting implications. Moreover, they provided far less certain indications than the other tenure variables modeled. The problem with the final two variables may be one of incomplete information. Only one side of the rental agreement has been examined here. The landlords' expectations, impressions, and demands should also be included if a more accurate picture is to emerge. Future research should consider landlord responses.

The existence of a partnership tended to be a marginally significant influence on adoption. Only in Washington did this variable have a significance level of more than 10-percent. The general direction of impact for this variable was negative and indicated that partnerships conserved less than those farmers working along or with a spouse. Most likely the more complicated decisionmaking entailed in a partnership slowed the adoption process. Partnerships may face more income concerns and have less ability to invest in conservation practices. If more than one family depends on a single farm income, the constraints on that income grow enormously. Only in Washington, for the number of practices used for the first time on owned land, did the variable exhibit a positive impact; but, the result was marginal.

Participation Factors

There were two measures of participation in the conservation delivery system (SCS and ASCS) used in the testing process. Both measures are indexes. The first was a rating by farmers of their participation in SCS programs and their use of technical assistance. The second measure was a dollar value of the technical and financial assistance provided to the farmer.

SCS had a clearly positive and significant impact on adoption behavior. SCS participation appeared more often as an important factor on owned land and more often for the number of practices used first. Participation did aid the level of adoption achieved, but apparently did not have broad effects on the change in that level for the time period of this study.

Two of the three times SCS program participation proved significant on rented land were for tests involving Tennessee. The other instance occurred for Missouri. SCS participation apparently had no impact on rented land for Alabama and Washington, and a generally limited impact in Missouri.

On the other hand, participation in SCS activities was important for all measures of adoption on owned land in Missouri. In Alabama and Tennessee, SCS was a significant influence on the level of adoption achieved and the number of practices used for the first time for owned land. However, Washington exhibited the least influence from SCS participation with that factor significant for only the number of first time adoptions on owned land.

SCS participation had an expected positive influence; it appears that SCS was more important for the type of conservation change than for the changes in overall conservation level. But it may be that the SCS became important at the outset of adoption or if the scale of conservation became large enough to add complicating factors in the farm operation.

The value of the delivery system assistance was a positive influence on adoption, but much less often than was SCS participation. Delivery system assistance was not really any more important overall on rented land than was SCS participation, but the instances of importance were quite different. Further, delivery system assistance is less important for the number of first time adoptions and more often significant for the level of conservation and the change in that level.

The level of conservation on owned land was affected by delivery system assistance in only Alabama. But, in Washington, both the level and the change in conservation on rented land were positively related to delivery system assistance. In Missouri, delivery system assistance affected owned land changes in adoption and most significantly for the number of first time adoptions. A significant impact existed in Tennessee for only the level of conservation on rented land.

The comparative lack of significance for this ASCS-related independent variable is not surprising. ASCS provides limited access to cost-share funds and likely did not cost-share with farmers for more than one individual practice per season; it certainly capped the amount a farmer could receive. SCS participation is not as equally limited. But taken together, both measures indicate a very strong role for the conservation assistance programs in adoption of soil erosion practices. In fact, the relative importance of these variables for Tennessee exceeded those of the other independent variables. In the other states, these variables numbered among the most influential when significant and were generally only exceeded in importance by the tenure status of the farmer.

Other Factors

Included in this final grouping are factors such as peer pressure, and off-farm work by the farmer or spouse.

Off-farm work was intended as a measure of outside financial assistance and was expected to aid the adoption of erosion control practices. However, this was apparently not true for the level of adoption achieved or the number of practices tried for the first time. Both off-farm work by the farm operator and off-farm work by a spouse exhibited negative relations to these two dependent variables. Only for the change in the level of adoption was the direction of impact positive and supportive of additional conservation activity.

In Tennessee, off-farm work by the farmer was a strong positive influence on changes in adoption on both owned and rented land. In Missouri, off-farm work by a spouse was positively related to changes of adoption on owned land only. In Alabama, however, the opposite was true, indicating that generalizations across states tended to be incorrect. Overall, this variable appeared to be measuring more than just financial stimulus. This variable may also have measured the amount of time an individual had available to address farm problems. A negative relationship more likely indicated a part-time farmer.

When significant, peer pressure exerts a positive impact on adoption. This was more true for rented land and especially so in Tennessee. Criticism by other farmers was apparently taken as a positive influence on rented land adoption for the level of use and the number of practices used for the first time. Peer pressure, however, was not an across-the-board causal variable. In only 3 of the 24 tests did it prove to be significant at a level less than 10 percent, with each of these being on rented land.

Some Generalizations On Factors Related To Adoption

Findings differed considerably among the states studied, therefore generalizations from the study are limited.

Factors affecting owned land were markedly different from those affecting rented land. In fact, the only variable showing near universal impact measured the tenure structure of the farm. That is, operating both owned and rented land appeared to have a negative impact on erosion control adoption, on either owned or rented land. Further research should explore in more detail the bounds separating owned from rented land adoption decisions. A better measure of the landlord's influence is needed.

There was, however, general agreement across states and dependent variables as to the direction of impact for certain factors. Education, SCS participation, delivery system assistance, written rental agreements, and landlord cost-sharing had clear positive influences when they proved to be significant. But, these factors were not consistently significant for the same state or dependent variable; consequently, a broadly based finding is not possible from the data.

Measures of debt, income, off-farm work, income time frame, management ability, the number of landlords, the number of years expecting to rent, the percent of farm income from crops, and the percent of the farm in row crops had mixed results. The direction of the effects on adoption of these factors tended to switch from test to test. The results for these variables cannot be generalized using the survey information.

It is unclear why a variable should shift signs in tests in different states. Shifting signs for different dependent variables can at times be explained. Factors affecting the level of adoption positively may indicate a negative relation to change in some cases. Shifting signs across dependent variables is a phenomenon of the way adoption is measured. But to find that a variable has a positive impact in one locale and a negative impact in another is at best puzzling. Without further knowledge of the structural, cultural, and social differences between regions, one finds it difficult to infer the causes of sign changes in cross-state comparisons.

One major conclusion provided by these data rests with the consistency of a variable across states and dependent variables. For some variables, the direction of influence was uncertain from state to state. A measure in one place can be indicative of something different in another place. Further, the choice of the dependent variable could determine the set of factors found to be significant and which may be equally true for the choice of region for study.

The fact that the impact of an explanatory variable is itself variable raises serious concerns. One could erroneously expect specific results in one region by basing that expectation on another region. Study results suggest a uniform impact across regions for an independent variable is the exception rather than the rule. Therefore, models pooling observations across regions may be suspect.

Finally, the choice of the dependent variable, the measure of adoption, provided a good deal of variability. The choice of measurement for the dependent variable may, in certain instances, preordain the set of factors found to be important to erosion control. A most crucial area for further research would be in defining a clear and common measure of erosion control that would have wide applicability and validity.

More research is needed to identify the sources of divergence between dependent variables. Defining the level of dependent variable measurement is perhaps a critical choice.[10] Divergence in previous empirical studies over independent variable impacts could be attributed to differing variables. Definition of erosion control is an important factor in designing a program to influence adoption. The proper measure of adoption is paramount to an accurate evaluation of program outputs.

Practice Specific Measures of Adoption

The factors affecting the use of terraces with grassed waterways and minimum or reduced tillage were examined for Alabama, Missouri, and Tennessee. Washington was excluded from the analysis of terraces with grassed waterways since it was not one of the eight practices most recommended for use in the state by the SCS. Minimum tillage was examined for Alabama, Missouri, and Washington. Tennessee was excluded from the analysis of minimum tillage since few farmers had used the practice, producing poor dependent variable data distributions. Poor or limited response distributions for other practices surveyed fostered this narrowed examination of factors affecting the adoption of specific practices. The data indicating the test results of these analyses are shown in tables 11-14.

[10] Ervin and Ervin make a similar point in their study of conservation in Missouri [17].

The dependent variables for each test of the practices were the 1983 use level of the practice expressed as a percentage of land operated and the change in the level of practice use on a percentage basis. These two variables are entirely equivalent in construction to the aggregate measures of adoption. The first time use of the practice was not considered for practice specific testing due also to poor data distributions.

Factors Affecting The Adoption Of Terraces With Grassed Waterways

Alabama. For Alabama, no single factor was significant at lower than a 0.10-level for both owned and rented land across both dependent variables. Income time frame shows a significant negative impact on adoption for three of the four tests. But no other variable was significant for more than two of the four regression tests.

Factors affecting the level of adoption on owned land (table 11) were education, income time frame, farm size, debt per acre, off-farm work by the spouse, partial ownership, and the total value of delivery assistance. For the same dependent variable on rented land, only income time frame, farm size, and partial renter were significant with each indicating a negative impact.

Education and income time frame had surprising negative effects on adoption level for owned land. Farm size, debt, and partial owner or renter had the expected negative signs and the delivery system had a positive effect. SCS participation had no significance and did not even enter the stepwise regression models. Financial, and not technical, assistance apparently was the key to the adoption of terraces in Alabama.

Results for the level of adoption of terraces did not necessarily contradict the results for the level of adoption as measured over all practices. But, the set of factors affecting the aggregate measure of adoption were not quite the same as those affecting the level of specific practice adoption in Alabama. Furthermore, relationships exhibited for education, income time frame, and debt towards the level of terrace adoption were more likely an indication of a correlation than a causal relationship.

Factors affecting the change in use of terraces on owned land were management ability, perceptions of the erosion problem, off-farm work by a spouse, partnership, and the total value of delivery system assistance. Off-farm work by a spouse had the opposite effect on change in adoption than on the level of adoption. Further, management ability, a variable highly related to education, had an opposite sign as compared with education's impact on the level of owned land adoption.

The rented land model (table 12) for change indicated that years operating the farm, income time frame, perceptions of erosion, and partial renter all significantly affected adoption. Again, the rented version of the model had fewer significant variables than its owned land counterpart. The mix of factors affecting owned land also differed quite a bit from the mix of factors affecting rented land.

Factors affecting changes in the level of use of terraces were similar to the factors affecting the aggregate measure of change, as explained in the previous sections. However, the number of variables that proved to be important in this practice's specific case were fewer than in the overall instance. It is quite possible for a factor to affect a specific practice, but not all practices in general or for the reverse to occur.

Table 11--Factors affecting adoption of terraces with grassed waterways, owned land, by state

Independent variables	Dependent variables with respect to adoption of terraces with grassed waterways					
	1983 level of conservation			Change in conservation, 1980 to 1983		
	Alabama	Missouri	Tennessee	Alabama	Missouri	Tennessee
A Personal factors:						
1 Years operating farm						
2 Education					++	
3 Management ability				++		
4 Degree of agrarianism					--	
5 Future farm ownership plans						
6 Risk attitudes						
7 Perception of erosion			++	+		
B Business factors:						
1 Gross farm income						
2 Debt per acre	--					
3 Debt/asset ratio						
4 Percent of income from crops						
5 Income time frame	--					
C Farm physical factors:						
1 Acres in farm	--	--				
2 Percent of farm in row crops		+				
3 1980 conservation effort	NA	NA	NA	--	++	
4 Erosion severity index		--				++
D Tenure and organizational factors:						
1 Partial owner/partial renter	--	-	--			
2 Rental agreement	NA	NA	NA	NA	NA	NA
3 Landlord-tenant cost-sharing	NA	NA	NA	NA	NA	NA
4 Years expecting to rent	NA	NA	NA	NA	NA	NA
5 Number of landlords	NA	NA	NA	NA	NA	NA
6 Partnership		--		++	--	
E Participation factors:						
1 SCS Participation score					++	++
2 Delivery system assistance		++		++		
F Other factors:						
1 Off-farm work by farmer						++
2 Off-farm work by spouse	--			++		
3 Peer pressure					-	

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variables.

A - sign means a negative statistically significant relationship between the dependent and independent variables.

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

Table 12--Factors affecting adoption of terraces with grassed waterways, rented land, by state

Independent variables	Dependent variables with respect to adoption of terraces with grassed waterways					
	1983 level of conservation			Change in conservation, 1980 to 1983		
	Alabama	Missouri	Tennessee	Alabama	Missouri	Tennessee
A Personal factors:						
1 Years operating farm				--	++	
2 Education						
3 Management ability						
4 Degree of agrarianism						
5 Future farm ownership plans	NA	NA	NA	NA	NA	NA
6 Risk attitudes						
7 Perception of erosion				++	--	
B Business factors:						
1 Gross farm income		++				
2 Debt per acre						
3 Debt/asset ratio						
4 Percent of income from crops						
5 Income time frame	--			--		
C Farm physical factors:						
1 Acres in farm	--				++	++
2 Percent of farm in row crops						
3 1980 conservation effort						++
4 Erosion severity index		--				
D Tenure and organizational factors:						
1 Partial owner/partial renter	--	--		--		
2 Rental agreement		+	++			++
3 Landlord-tenant cost-sharing						
4 Years expecting to rent		-			+	
5 Number of landlords						
6 Partnership					--	
E Participation factors:						
1 SCS Participation score						
2 Delivery system assistance		--	++			
F Other factors:						
1 Off-farm work by farmer						
2 Off-farm work by spouse						++
3 Peer pressure		--				+

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variables.

A - sign means a negative statistically significant relationship between the dependent and independent variables.

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

Missouri. The sets of significant variables in Missouri are not the same as that for Alabama. Factors affecting the level of owned land adoption in Missouri included risk, farm size, the percent of the farm in row crops, partial ownership, partnerships, and the weighted erosion index (the measure of relative erosion severity). For rented land, the factors were gross farm income, partial renter, weighted erosion index, delivery system assistance value, peer pressure, rental agreement, and years expecting to rent.

Farm size in acres had a negative impact on the level of adoption on owned land, yet farm income had a positive impact on the level of rented land adoption. These two measures of size were not equivalent across land tenure classifications. The weighted erosion index had the same negative effect for both owned and rented land. The index appeared to be indicating that the more land classified as severe led to less adoption of terraces, which is at best counterintuitive. Perhaps this result is exploratory and even the artificate of a statistical process and not theoretically relevant.

Factors affecting the change in use of terraces with grassed waterways on owned land in Missouri included education, farm orientation, partnership, SCS participation, base conservation efforts, and peer pressure. This degree of agrarianism and peer pressure had opposite signs than expected. SCS participation was, for the only time in this set of tests, a significant positive factor in adoption. Partnership was another negative influence on adoption in Missouri. This was true for both dependent varibles with respect to owned land and with regard to one dependent variable for rented land.

Factors affecting rented land change in Missouri were years operating the farm, perceptions of erosion, farm size in acres, partnership, and years expecting to rent. Years expecting to rent had a positive effect on adoption change, but had the opposite impact on the level of adoption on rented land. Partnership had a continued negative impact on adoption, but farm size reversed signs from previous tests for other dependent variables.

Tennessee. The 1983 level of adoption of terraces with grassed waterways on owned land was significantly affected by perceptions of erosion, partial ownership, and participation in SCS activities. The level of adoption on rented land was affected by only the type of rental agreement and total delivery system assistance value. SCS primarily affected owned land change while the ASCS-dominated variable primarily affected rented land.

Factors affecting the change in use of terraces with grassed waterways on owned land were off-farm work by the operator, weighted erosion index, SCS participation, and base conservation efforts. Factors affecting changes on rented land were farm size, off-farm work by the spouse, base conservation efforts, and the type of rental agreement. All the above factors had a positive relation to adoption.

Base conservation effort did not have the expected sign for change in adoption. The positive influence of this variable may indicate that levels of previous adoption make it more likely that a new or additional use of terraces will be undertaken. Most likely, a previous use allows a phase of learning that favorably influences the adoption process.

Tennessee exhibited a good deal of divergence from the results for Missouri and Alabama. Each state stood clearly separate with a varying set of factors affecting adoption. But as was true for Alabama and Missouri, there were some similarities in the state between the factors affecting the adoption of a specific prac-

tice and those affecting any type of adoption. Yet, the similarities between the specific and general cases were limited and disallow broad generalizations in either direction.

Policy based on the general case could easily prove incorrect for the specific type of adoption or even the state considered.

Factors Affecting The Adoption Of Minimum Tillage

Factors affecting the adoption of minimum tillage practices were analyzed for Alabama, Missouri, and Washington. These factors generally differed from those affecting terraces in those states where comparisons can be made (Alabama and Missouri). Further, the important exploratory variables tended to differ from the set of factors influencing aggregate measures of adoption for the same state, which was also true for the set of factors affecting the use of terraces.

Alabama. Years operating the farm, education, degree of agrarianism, perceptions of erosion, off-farm work by a spouse, and participation in SCS activities all showed significant statistical effects on the level of adoption on owned land. The level of adoption on rented land was significantly affected by management ability, partial renter, the number of landlords, the type of rental agreement, and landlord-tenant cost-sharing.

Factors significantly influencing changes in minimum tillage use on owned land (table 13) were degree of agrarianism, farm size in acres, and base conservation efforts. Change in rented land adoption was affected by off-farm work by the farm operator, the number of landlords, the type of rental agreement, and the number of years expecting to rent.

Where significant, the variables for years operating the farm and education both had negative impacts on adoption. Management ability had a positive impact on the level of adoption on rented land only. Degree of agrarianism had the expected positive relation to adoption for owned land, but was not even significant enough to be entered into the model for rented land. Farm size and off-farm work by the farm operator provided positive influences on the change in adoption, but for differing land tenure types. The SCS participation variable was important for only the level of adoption on owned land.

The number of landlords and the type of rental agreement had positive effects on rented land adoptions (table 14). Written contracts and more landlords appeared as favorable influences: the longer one expects to rent, the greater the likelihood of adoption on rented land. However, this effect was strong only for the change in minimum tillage use in Alabama. Perceptions of erosion and landlord tenant cost-sharing exhibited signs that were opposite the direction expected. Such odd results, a bit confounding and not readily explainable, should be considered exploratory, needing further verification.

Missouri. Factors affecting owned land level of adoption in Missouri for minimum tillage were years operating the farm, percent of farm in row crops, off-farm work by the farm operator, partial ownership, and partnerships. Rented land adoption level was in turn influenced by education, farm size in acres, debt-asset ratio, participation in SCS activities, landlord-tenant cost sharing, and the number of years expecting to rent.

On rented land, the positive impact of the debt variable might not be counter-intuitive. One might expect that higher debts inhibit further adoption,

Table 13--Factors affecting adoption of minimum tillage, owned land, by state

Independent variables	Dependent variables with respect to minimum tillage					
	1983 level of conservation			Change in conservation, 1980 to 1983		
	Alabama	Missouri	Tennessee	Alabama	Missouri	Tennessee
A Personal factors:						
1 Years operating farm	--	--			-	--
2 Education	--					
3 Management ability			+			
4 Degree of agrarianism	++		++	++		
5 Future farm ownership plans					+	
6 Risk attitudes					++	
7 Perception of erosion	--					
B Business factors:						
1 Gross farm income						
2 Debt per acre						
3 Debt/asset ratio						
4 Percent of income from crops						
5 Income time frame					-	
C Farm physical factors:						
1 Acres in farm				++		
2 Percent of farm in row crops		++			++	
3 1980 conservation effort				--	--	
4 Erosion severity index						
D Tenure and organizational factors:						
1 Partial owner/partial renter		--	--		--	--
2 Rental agreement	NA	NA	NA	NA	NA	NA
3 Landlord-tenant cost-sharing	NA	NA	NA	NA	NA	NA
4 Years expecting to rent	NA	NA	NA	NA	NA	NA
5 Number of landlords	NA	NA	NA	NA	NA	NA
6 Partnership		++				--
E Participation factors:						
1 SCS Participation score	++					
2 Delivery system assistance			-		--	
F Other factors:						
1 Off-farm work by farmer		--				
2 Off-farm work by spouse	--				++	
3 Peer pressure						++

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variables.

A - sign means a negative statistically significant relationship between the dependent and independent variables.

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

Table 14--Factors affecting adoption of minimum tillage, rented land, by state

Independent variables	Dependent variables with respect to minimum tillage					
	1983 level of conservation			Change in conservation, 1980 to 1983		
	Alabama	Missouri	Tennessee	Alabama	Missouri	Tennessee
A Personal factors:						
1 Years operating farm			--	++		
2 Education		++				
3 Management ability						++
4 Degree of agrarianism			--			
5 Future farm ownership plans	NA	NA	NA	NA	NA	NA
6 Risk attitudes						
7 Perception of erosion			++		--	
B Business factors:						
1 Gross farm income					++	
2 Debt per acre						
3 Debt/asset ratio		++			++	
4 Percent of income from crops					++	
5 Income time frame						
C Farm physical factors:						
1 Acres in farm		++				+
2 Percent of farm in row crops						
3 1980 conservation effort					--	-
4 Erosion severity index						+
D Tenure and organizational factors:						
1 Partial owner/partial renter	--					
2 Rental agreement	++			++		
3 Landlord-tenant cost-sharing	-	++	--			
4 Years expecting to rent		+		++		--
5 Number of landlords	++			++	++	-
6 Partnership			--			
E Participation factors:						
1 SCS Participation score		--				--
2 Delivery system assistance						
F Other factors:						
1 Off-farm work by farmer				++	+	
2 Off-farm work by spouse			--			
3 Peer pressure						

NA: Not applicable.

A + sign means a positive statistically significant relationship between the dependent and independent variable

A - sign means a negative statistically significant relationship between the dependent and independent variable

A single + or - sign means statistically significant in the range of 0.11 to 0.15 levels of significance.

A double ++ or -- sign means statistically significant in the range of 0.01 to 0.10 levels of significance.

A blank space means that no significant relationship was found between indicated variables.

especially adoption of structures. But, for minimum tillage, higher debt might induce adoption for economic reasons. If minimum tillage provides lower costs of production, the higher debt level will foster adoption as the farmer seeks to reduce production costs.

The negative impact of SCS might also be explainable. If the local area office is more oriented to structural types of conservation practice, then farmers considering minimum tillage would need to go to other sources for information or technical assistance.

The change in the use of minimum tillage practices on owned land in Missouri was negatively affected by the number of years operating the farm, the income time frame, partial ownership, base conservation efforts, and delivery system assistance. Adoption was positively influenced by future farm ownership plans, risk, off-farm work by a spouse, and the percent of the farm in row crops. These results tend to agree with those found in Missouri.

Rented land changes were affected by off-farm work by the farm operator, farm income, debt-asset ratio, the percent of farm income from crops, and the number of landlords. These effects were all in a positive fashion, at a statistically significant level of 15 percent or less. Rented land changes in minimum tillage use were negatively affected by base conservation efforts and perceptions of the erosion problem at a 10-percent level or less.

Results for rented land changes tended to deviate from the general Missouri case for change in adoption behavior. The overall model proved nonsignificant with no variables affecting change at a 10-percent level or less. The adoption of minimum tillage is, however, affected by some six independent variables at a 10-percent level or less. Again, general case models may be less important than expected.

Washington. The level of use of minimum tillage on owned land in Washington was significantly affected by degree of agrarianism and partial ownership, but only marginally by delivery system assistance. On rented land, the level of adoption was influenced by years operating the farm, degree of agrarianism, perceptions of erosion, off-farm work by a spouse, partnership, and landlord tenant cost-sharing.

The change in the use of minimum tillage on owned land appeared to result from the number of years farmed, partial ownership, partnership, and peer pressure at a statistically significant level of 10 percent or less. Change in conservation on rented land resulted from management ability, farm size in acres, weighted erosion index, SCS participation, base conservation efforts, the number of landlords, and the number of years expecting to rent at a 10-percent level or less.

Some Generalizations On Specific Practice Adoption

Specific practice adoption appeared to be an event resulting from variable sets of influences. The major influences are not entirely clear from this analysis since differing sets of independent variables became important at varying times, depending on the state and the measured dependent variable. These conclusions are quite similar to those for the aggregate measures of adoption discussed earlier.

Factors Affecting Inclinations Towards Adoption

The final analysis employed discriminant function analysis of the factors determining a farm operator's change in inclinations towards erosion control adoption (table 15).

Table 15--Summary of discriminant analysis results with respect to farmers' inclination to adopt erosion control practices, owned and rented land, by state

Independent variables	Direction of influence of independent variables on the index of farmers' inclination to adopt erosion control practices			
	Alabama	Missouri	Tennessee	washington
A Personal factors:				
1 Years operating farm	-	-		+
2 Education	+	+	+	
3 Management ability				+
4 Degree of agrarianism	+			
5 Future farm ownership plans				
6 Risk attitudes	+			-
7 Perception of erosion	+			
B Business factors:				
1 Debt per acre	-			
2 Income time frame	-	+	+	
C Farm physical factors:				
1 Acres in farm	-	+	+	+
2 Percent of farm in row crops				NA
3 Erosion severity index	+			+
D Tenure and organizational factors:				
1 Percent of farm rented (a)	+		+	
2 Partnership				+
E Participation factors:				
1 SCS Participation score	+		+	+
2 Delivery system assistance				
F Other factors:				
1 Off-farm work by farmer	+	-		
2 Off-farm work by spouse				
3 Peer pressure	+	+	+	-

NA: Not applicable.

A + sign means a positive statistically significant relationship between the index of farmers' inclination to adopt erosion control practices and the indicated independent variable.

A - sign means a negative statistically significant relationship between the index of farmers' inclination to adopt erosion control practices and the indicated independent variable.

(a): This variable substitutes for the partial owner/partial renter variable specified in other analyses.

In Alabama, the most significant discriminators were, in order of importance, education, the weighted erosion index, years operating the farm, and income time frame. Additional importance variables for this state model were: perceptions of county erosion, peer pressure, farm size, and the percent of the farm rented. Education had a positive influence on changes in inclinations to adopt erosion

control, as did the weighted erosion index (the severity of the erosion problem), peer pressure, the percent of the farm rented, and perceptions of the county erosion problem. Years operating the farm, income time frame, and farm size suggested less inclination towards adoption in Alabama.

The model results for Missouri were only somewhat similar to those for Alabama. The Missouri model had much fewer important variables and exhibited opposite signs for income time frame and off-farm work by the farm operator, compared with Alabama. The Missouri model agreed with the Alabama results with regard to years operating the farm, education, and peer pressure. In Missouri, a longer term view fostered inclinations towards more adoption while off-farm work by the operator had the reverse effect.

The Tennessee model indicated that more inclination towards adoption is positively related to farm size, percent of farm rented, income time frame, and peer pressure. Education and SCS participation were also positively related to more inclination towards adoption.

The model for Washington agreed with some of the findings for the other states, but differed considerably over the impact of years operating the farm, peer pressure, and risk. Partnership and weighted erosion index were far and away the most significant variables affecting inclinations in Washington. Management ability, education, and farm size were other important variables affecting inclinations.

There were more similarities among states with regard to inclinations to adopt erosion control practices than for any of the other three dependent variables tested in the regression results reported above. The discriminant models were all significant, with the Alabama model exhibiting a little stronger explanatory ability. However, the generalization of specific variable results to all states was as problematic as it was for the previous analyses of adoption. In only two cases, for the percent of the farm rented and the SCS participation variable, did the directions of impact agree across states. And even in the two instances where they do agreed, the result was not significant for all states.

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VIII. APPENDIX: METHODOLOGY FOR MODELING

Outlined in the following sections are the procedures and methods used in the statistical modeling of erosion control adoption. The models presented here employ a general linear regression or discriminant analysis concept and present the adoption decision as a dependent result of a series of independent and causal factors. The models presented recognize that the adoption process is affected by a series of variables that can at times be either conflicting or reinforcing. The statistical methods and models follow the general findings of the literature briefly surveyed in the body of the report and referenced in the bibliography.

Measures of 1983 Level of Conservation Use

This dependent variable was first defined for each state as the percentage of sample farmland to which any or all of the applicable conservation practices were being used. For each state, a series of eight recommended practices was surveyed and data were collected on the number of acres of owned and/or rented land that received or was affected by each of the specified erosion control treatments in 1980 and 1983. The acres listed by the farmer for each of the eight practices in 1983 were summed and divided by the total number of acres operated in 1983. Owned land responses were kept separate from rented land responses.

The 1983 level of conservation use expresses adoption behavior as a percentage measure for each land tenure type (owned or rented) with respect to that total farm operation. But this 1983 level is a point in time measure indicating the end point of a process. The 1983 level essentially measures the cumulative amount of erosion protection employed by the farmer on a percentage basis and therefore is an essentially static measure of adoption behavior.

This measure is intended to reflect the level of protection achieved for owned or rented land from soil erosion problems. It is by no means a perfect measure of the efficiency, appropriateness, or success of the applied practices, but it is a measure of the extent to which practices have been applied at a point in time.

This same type of dependent variable was also defined on a per practice basis. In such instances, the listed acres in 1983 for a single specific practice were divided by the total farm acres operated. In these cases, the variable was defined to be the 1983 level of specific practice use. Again, adoption on owner-operator land was separated from rented land adoption with the variables expressed on a percentage basis.

Measures of Adoption Change

Two variables were used to define change measures. The first was generated as an overall and a practice-specific measure. The second change measure, explained in the following subsection, was defined as an overall measure and not applied on a per practice basis.

Erosion control practice adoption may be measured at a point in time, but it is actually a process. The measures of adoption change used as dependent variables in this study attempt to gauge the movement in the adoption process. As noted earlier, data were collected on practice adoption levels for eight practices in each state for both 1980 and 1983. The difference between those 2 years defined the change in adoption we chose to measure.

An overall measure of change was defined as the sum of the differences between 1980 and 1983 acres under conservation practice use across all practices, and

divided by the total acres operated. Owned land was kept separate from rented land. The overall measure of change is then a percentage index of total net adoption activity for 1983 compared with 1980. Including all applicable practices, this overall change variable is intended as a broad index of adoption behavior, per land tenure type.

As was done for the 1983 level of adoption measures, changes in adoption were also defined on a practice-specific basis. For each practice separately, the change in acres in that practice, for either owned or rented land, was divided by the total number of acres operated. This produced a percentage index of change for each separate practice, but model testing was limited to two practices.

Practices Used for the First Time

The change variable described above measures both ongoing and brand new adoption behavior as essentially the same thing. This second change variable attempts to single out those who are adopting a practice for the first time. It is based on a comparison of 1980 and 1983 use levels of each practice surveyed per state.

The practices used for the first time variables were expressed as the number of practices that the surveyed farmer had tried in 1983 but had not used in 1980. Use of practice for the first time meant some positive level of acres under the practice in 1983 and no acres under the same practice in 1980. The variable as defined has a potential range from 0 to 8, but actually ranged from 0 to 5. No farmer surveyed had tried all eight of the applicable practices for the first time between 1980 and 1983.

This variable was defined for owned land separate from rented land and was used only on an overall basis. No comparable practice-specific variable was defined for first time use. The actual number of farmers using any single practice of the first time was too limited to make a practice-specific version workable. Further, a practice-specific version of first time use would most likely be expressed as binomial variable, and these types of dependent variables are known to offer statistical difficulties for regression analysis.

Practice-Specific Dependent Variables

As mentioned earlier, level and percentage change dependent variables were measured on an overall basis (that is, across all practices considered) and on a single practice level. However, only two specific practices were actually tested for the 1983 level and percent change versions of the dependent variables.

The use of terraces with grassed waterways was constructed as a 1983 percent-level dependent variable and as a percent-change dependent variable for Alabama, Missouri, and Tennessee. Washington was excluded since the terrace with grassed waterway was not one of the surveyed practices in that state. The use of minimum tillage for erosion control was the other practice-specific dependent variable constructed. Minimum tillage use was also defined as a level, and percent-change variable, but only for Alabama, Missouri, and Washington. Tennessee was excluded from the tests for minimum tillage since few farmers had used the practice and almost no distribution of response existed.

All other specific practices were precluded from a separate case analysis due to poor response distributions. Although the sum of practice use across all practices provided good data, the distributions for each practice separately were comparatively disappointing. The lack of response range for the remaining

practices disallowed any meaningful testing of separate practice adoption. Thus, aside from terraces with grassed waterways and minimum tillage, the data dictated the more broadly defined measures of erosion control adoption outlined here.

Inclinations Towards Adoption

This dependent variable represents a somewhat separate and special case. This variable, as defined for testing a discriminant analysis, is a binomial measure of the change in farmers' attitudes towards practice adoption. The variable is used on the five-point question in the farm survey questionnaire that asked farmers to rate the change in their willingness to adopt erosion control mechanisms. The question required farmers to indicate whether they were (1) much more inclined, (2) slightly more inclined, (3) slightly less inclined, (4) much less inclined, or (5) had about the same inclinations towards adoption in 1983 as they had in 1980. The categories indicating an increase in inclinations were combined and coded as a value of 1 while the categories indicating less inclinations or no change were condensed and recoded to a value of 0.

This two-part categorization was then used to test the potential change in attitudes over the same time period that the targeting program was initiated. It has been argued that, with erosion control being a process, it is as important to consider the impact of shifting attitudes as it is to study the actual end result decision to adopt. This variable allows testing attitudes as a dependent variable.

In summary, three versions of a continuous measurement dependent variable were applied to tests of overall adoption behavior. Two of the continuous measurement dependent variables were replicated for single practices for a subset of the states in the sample. In all cases, owned land was considered separate from rented land, meaning that two versions of the same dependent variable were created simultaneously. A final separate binomial variable was created to measure attitude changes toward adoption. This final variable was treated as a somewhat special case with a separate statistical methodology applied (discriminant analysis instead of regression analysis).

Independent Variables

The variables outlined in the following subsections are those retained for statistical testing. These variables represent the set of factors affecting adoption considered to be most relevant according to the criteria established earlier. The subsections to follow organize the independent variables into general categories consistent with the groupings presented in the conceptual model illustrated by figure 1.

Personal Factors

The variables in this grouping all tend to measure some individual characteristic of the farm operator interviewed. Factors include years farmed, education, management ability, farm orientation, farm disposition, risk attitudes, and perceptions of the erosion problem.

Years farmed, as an independent variable, measures the actual number of years the surveyed farmer has operated the oldest part of the farm unit. This variable can be a proxy for age, farming experience, and/or the acquired knowledge of how to handle the land operated. It is not clear from the literature the exact direction of influence years farmed may have on adoption. If years farmed represents

knowledge or experience, it should positively affect adoption. If years farmed, however, is more of an age measure, the impact can be either positive or negative according to previous empirical efforts.

This variable was chosen in our analysis as an alternative to direct measures of age. Age as an independent variable exhibited bothersome intercorrelations with education, ownership, farm size, debt, risk, and income. Years farmed, since it is not entirely a measure of age, had acceptable levels of correlation to other dependent variables.

Education was originally measured categorically in the farm survey with the respondents indicating the highest level they had achieved. The categories were recoded to numeric values to imply a somewhat continuous level of measurement. Education was expected to have a positive influence on adoption as indicated in the research literature.

Managerial ability was devised as an index measure ranging from 0 to 20 and included years farmed, education, use of consultants and outside sources, and the use of a computer in the farm operation. The higher the number, the more sophistication in the farm operation. This variable was tested in runs separate from education or years farmed since both these variables were components of the managerial index. Problems of multicolinearity dictated the separate treatment.

Future farm ownership plans was a binomial variable in the models designed to measure the operators' plans for the farm. If the operator planned to pass the farm to another family member, this variable had a value of 1; otherwise it had a value of 0. It was expected that family ties would have a positive influence on adoption. This variable was not applied to tests on rented land. It is, in part, a measure of stewardship on owner-operated land.

Degree of agrarianism was another binomial independent variable and was intended to measure agrarianism. This variable had a value of 1 if operators viewed farming as a way of life and a value of 0 if they had viewed farming as a business. Less stress on explicit economic returns for investments was thought to be more conducive for positive adoption behavior.

Risk attitudes are considered an important influence on practice adoption. Erosion control methods are often viewed as new, untried, or risky activities by farmers. If such is clearly the case, then greater tolerance for risk should be associated with more adoption behavior. The variable measuring risk was a continuous-level-index variable constrained to be between a value of 1 to 5. A value of 5 indicated strong risk acceptance while a value of 1 may be viewed as strong risk avoidance.

Perception of the erosion problem in the county was the final personal variable included and it too is an index value. This index ranges from 1 to 5 and is based on farmers' ratings of the severity of seven erosion-related problems in their county. It was expected that greater perceptions induce more adoption; the ability to recognize the existence of a problem is viewed as a critical step in the decision to adopt.

Business Factors

The independent variables in this grouping are intended to measure aspects of the farm business surveyed. Business factors included gross farm income, debt,

debt-asset ratio, percent of income from crops, and income time frame. All these variables were originally measured categorically, and the values used for these variables in the models were the median values implied by the category ranges.

Gross income was expected to exhibit a positive influence on adoptive behavior. This variable was not tested in all the models and was excluded from models which included acres operated. In fact, farm size was used as a proxy for this variable since it is the variable more readily observed by the action agencies.

Debt per acre was the first of two variables designed to measure the financial conditions facing the farm operator. This variable was constructed as the sum of operating and real estate debt divided by total acres operated. Note that the component of the numerator in this variable was derived from a series of recodings. This is really a relative measure of debt, but it was expected that higher debt levels constrain adoption. Since many practices that control erosion require investments, higher debt levels would signal an inability to either raise the necessary investment or handle the additional cash flow burden. This variable was tested separately from risk and tenure factors due to intercorrelation problems.

Debt-asset ratio was the second measure designed to define financial conditions on the farm. The debt level was the same as for the numerator in the debt per acre variable. The denominator in this ratio was also derived from the medial values of the responses to categorical ranges for 1983 asset values. Assets were defined to include land, equipment, and other investments. Large ratios were expected to have the same impact as the other debt measure.

The percent of income from crops was considered to be a proxy measure for a lack of flexibility in the farm operation. The greater the percentage the less the farmer is seen to be able to switch land out of production for crops and into other uses, or to be able to handle the possible constraints a practice adoption may impose. Again, this variable is generally an approximate measure resulting from a recoding scheme to reflect median values of a range. This debt measure was also tested separately from the risk and tenure measures due to variable intercorrelations.

The income time period concern was the final business variable included. This variable was intended as a measure of short- versus long-term views. Adoption is seen as constrained by short-term concerns since erosion control investment has a benefit stream stretching to the longer term.

Farm Physical Factors

These variables include farm size (in acres), the percent of the farm in row crops, a weighted erosion severity index, and a measure of 1980 conservation levels.

Farm size refers to the total number of acres the respondent operated in 1983. It includes owned and rented acres farmed by the operator, but does not include acreage leased to another farmer. This variable measures the scale of an operation and provides a proxy measure for gross income levels. Farm size has been generally associated with more adoption of erosion control, although the relationship may be curvilinear.

The percent of farm acres devoted to row crops (corn, peanuts, cotton, soybeans, and grain sorghum) was considered to be a measure of the impact of farming

practices on adoption behavior. Row crops are generally considered to be major causes of erosion in farming. Higher percentages of row cropping are thought to indicate more land use intensity and less practice control adoption. The sum of acres harvested in corn, peanuts, cotton, soybeans, and grain sorghum was divided by the total acres operated to yield this percent measure. This variable was not defined for Washington.

Base conservation efforts were measured as the percent of the cropland per farm that had received any or all of the recommended conservation treatments in 1980. This variable was intended as a measure of where the farmer was with regard to erosion control in 1980. A farmer with a high degree of conservation in 1980 may not need additional protection and may only need to maintain the current level. However, some level of conservation in 1980 could be associated with more in 1983. It is hypothesized that some exposure to conservation in 1980 may encourage further adoption later. Once practices are tried, adoption becomes a known rather than an unknown experience.

Erosion severity of the farm as rated by farmers was the final physical variable constructed. Farmers were asked to list the proportions of their owned and rented lands that they considered to have severe erosion problems, moderate erosion problems, and little or no erosion problems. The percentages indicated were required to sum to 100, or the total of owned or rented land operated. The percentages listed in the severe category were multiplied by a value of 3, while those listed for the moderate category were multiplied by a value of 2. These values were in turn summed and added to the percent listed as having little or no erosion problem. This grand total could range from a value of 100 to 300. It would be 100 if all the land were considered to have no erosion problem, and 300 if all the land were considered to have a severe problem. The grand total was then divided by 100 to yield an index between 1 and 3.

Organization or Tenure Factors

Variables in this group tend to be primarily binomial variables; the majority deal with issues of tenure. These factors tend to measure the sources of outside influence on adoption behavior. The primary tenure variable measures whether the farm operation uses owned and rented land, solely owned land, or solely rented land. Actually, this measure exists as two separate binomial variables: one each for owned land and rented land applications. The variable used in tests of owned land adoption behavior had a value of 1 if the farmer operated both owned and rented land in the entire operation, and a value of 0 if only owned land were operated. The variable used in tests of rented land adoption behavior again had a value of 1 if the farmer operated both owned and rented land in the entire operation, but took on a value of 0 if only rented land were used in the farming operation. These two variables are referred to as "partial or full ownership" and "partial or full renter."

The above variables, to a certain extent, measure structural factors affecting erosion control adoption. Across the sample, those farmers operating both owned and rented land tended to be fairly young, had higher debt-asset ratios, operated more land, and had larger gross farm incomes. In Alabama and Tennessee, partial owners tended toward a higher percentage of income from crops, while the renters for these states and Missouri tended toward greater percentages of row crops, especially on rented land. Full renters tended to be the youngest farmers surveyed, while full owners were the oldest. The partial owners did not appear to be the farmers who pushed toward larger operations and were the most hindered by current farm prices and finances.

Several tenure variables were applicable only for the analysis of rented land. The type of rental agreement was measured as a binomial variable that had a value of 1 if the rental agreement was a written contract, and a value of 0 if a verbal agreement. It was thought that a written agreement provided clarity and somewhat more stability to the rental assignment and would therefore be more conducive to practice adoption on rented land.

The existence of landlord-tenant cost-sharing for erosion control was another binomial variable. If the landlord had shared costs with the tenant in the adoption of erosion control mechanisms, a score of 1 was recorded, and if no sharing occurred a score of 0. The existence of sharing was thought to be an inducement to erosion control since it allowed the tenant a better potential economic payment and provided the tenant with some assurance that the landlord would not reap all the benefits of erosion control.

The number of years expecting to rent was an additional independent variable designed to measure stability and the presence of long-term potential to adoption on rented land. This variable was originally measured categorically and was recoded.

The final tenure variable measured the number of landlords the renter rented from. This was a continuous-level measurement variable ranging from 1 to 30 for the entire sample.

The major organizational variable measured the existence of a partnership in the farm operation. If the farmer operated alone or with only a spouse, this variable was coded as 1; otherwise a value of 0 was recorded. Partnerships could induce adoption of they were arrangements that added expertise and financial ability. Partnerships could, on the other hand, inhibit conservation by adding a layer of complication or a competing philosophy.

Participation Factors

There are two measures of participation in the conservation delivery system (SCS and ASCS) used in the testing process. Both measures are indexes. The first is a rating by farmers of their participation in SCS programs and their use of technical assistance. The second measure is a dollar value of the technical and financial assistance provided to the farmer.

The farmer's rating of participation in SCS was measured as an index score with a possible range of 0 to 25. A value of 0 indicated no contact or use of SCS in any way. A value of 25 meant extremely close and ongoing contact and participation with SCS. The score was based on a scaling that included attendance at demonstrations, SCS field visits, visits to the SCS office, use of a cooperative agreement with the SCS, and the existence of a farm plan. As indicated in the conceptual model, participation was envisioned as a major contributor to the adoption of soil conservation practices.

The total value of delivery system assistance was the second participation variable included in the models. This variable was the sum of ASCS cost-share assistance for 1982 and 1983 and the sum of the product of the hours of SCS technical assistance provided to the farmer and a cost per hour figure. The cost per hour figure reflected SCS' costs to provide technical assistance. These figures, when multiplied by the hours provided to the farmer, gave a rough valuation of the dollar equivalent of technical assistance received. This dollar

value of SCS assistance plus ASCS cost-sharing provided a total measure of federal assistance received.

Other variables concerned with delivery system participation were generated and rejected. Many of the rejected measures caused serious multicolinearity problems in the models within which they were tested. The variables enumerated in the previous paragraphs provided the broadest measures of participation considered and yielded none of the intercorrelation problems encountered with alternative versions.

Other Factors

Two variables measuring possible financial effects and a third measuring the impacts of community attitudes were also included in the model testing phase. All three are binomial measures.

Statistical Methods

The primary method of analysis of the factors affecting erosion control was a multiple regression. Regression analysis was conducted for each of the specified dependent variables. Separate analyses were conducted for owner-operated and rented lands for each state. Over 70 final regression tests were completed. The general approach assumed a linear equation with adoption as dependent upon a set of independent and causal variables.

The dependent variable specified as a measure of farmer inclination to adopt was, as mentioned earlier, tested using discriminant analysis. Discriminant analysis attempts to determine the set of variables which are most significant in classifying an event. It is most useful for identifying variables associated with discrete levels of a dependent variable.

The following subsections outline in further detail the organization of the tests conducted. However, a complete review is not presented. The discussion assumes that the reader has some understanding of the statistical techniques employed.

Regression Modeling

It was decided to identify a common model specifying a more limited set of independent variables for regression testing. Obviously, not all 27 variables were appropriate in the same regression test since some were substitutes. On the other hand, the independent variables considered were all plausible factors.

For all the measures of adoption behavior, the analysis progressed along two levels. First, a generalized model that contained a reduced set of key independent variables was identified. After regression tests were performed on this model for each state, a core set of the most significant independent variables was singled out. This core set then provided the basis for hierarchal stepwide regression analysis over the remaining nontested independent variables.

From an analysis of the intercorrelations of the independent variables, sets of variables that could not be tested together without creating undue problems were identified. Further re-examinations of the literature and consultations with other researchers identified a core set of variables important from theoretical and policy viewpoints. From these examinations, a general model was fashioned to include the following independent variables:

1. Risk
2. Farm size
3. Base conservation efforts
4. Weighted erosion index
5. Tenure type
6. Years farmed
7. Education
8. Future farm ownership plans
9. Degree of agrarianism
10. Income time frame
11. Off-farm work by the operator
12. Farmers' rating of SCS participation
13. Total delivery assistance
14. Type of rental agreement
15. Landlord-tenant cost-sharing

From the regression tests on the above general model, a core set of significant variables were identified. These variables formed the set of variables that remained in a hierarchal stepwise regression procedure during the second level of analysis.

In a stepwise regression, the statistical process chooses the variables to be included in the model. In a hierarchal stepwise regression, the research forces the process to retain certain variables in the model while allowing the statistics to choose the other variables to be included in the model from a remaining set. The hierarchal stepwise regression is a valid process when a researcher knows that certain variables are to be important but wants to see what other variables might also prove significant in combination with those known. The 12 remaining independent variables (those not tested for the general model) that were allowed to be stepped into the hierarchal regression models were:

16. Management ability
17. Perceptions of erosion
18. Gross farm income
19. Debt per acre
20. Debt-asset ratio
21. Percent of farm income from row crops
22. Percent of farm in row crops
23. Off-farm work by a spouse
24. Partnership
25. Peer pressure
26. Number of landlords
27. Years expecting to rent

Discriminant Modeling

The discriminant analysis procedure used a linear combination approach to determine factors of association between categories of the dependent variable and levels of the independent variables. The results of a discriminant analysis provide indications as to which independent variables provide the means for an accurate categorization of farmers' changes in attitudes towards adoption.

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